CONTROLLED READING

THE UNIVERSITY OF CHICAGO PRESS, CHICAGO
THE BAKER & TAYLOR COMPANY, NEW YORK; THE CAMBRIDGE UNIVERSITY PRESS, LONDON; THE MARUZEN-KABUSHIKI-KAISHA, TOKYO, OSAKA, KYOTO, FUKUOKA, SENDAI; THE COMMERCIAL PRESS, LIMITED, SHANGHAI

CONTROLLED READING

A CORRELATION OF DIAGNOSTIC, TEACHING, AND CORRECTIVE TECHNIQUES

BY EARL A. TAYLOR

Bureau of Visual Science
American Optical Company

THE UNIVERSITY OF CHICAGO PRESS
CHICAGO · ILLINOIS

 PUBLISHED FEBRUARY 1937. COMPOSED AND PRINTED BY THE UNIVERSITY OF CHICAGO PRESS, CHICAGO, ILLINOIS, U.S.A.

PREFACE

At the present time no subject in the entire school curriculum is receiving so much attention as reading. This intense interest probably results, in part, from society's demand on the schools for efficient readers—a demand which can be met only by the diagnosis and correction of the various reading deficiencies found among the school population, and by preventive measures which will eliminate, to some extent at least, reading disabilities. Unfortunately, a large group of students in every community cannot respond fully to educational techniques until remedial measures are employed. Visual inefficiencies, for example, seriously retard many pupils, for the whole educational scheme of teaching and learning in this country has evolved around and depends upon the function of vision. Interest in reading is stimulated also by the fact that numerous adults are desirous of improving their own reading ability, and are becoming tremendously interested in reading techniques. It is recognized that the ability to read comfortably, rapidly, effectively, and with minimum fatigue is an asset in our ever changing society.

It is an economic necessity, therefore, that educators carry on a vigorous program of preventive

as well as remedial work in reading, which will tend to eliminate, or greatly reduce, the number of those who, on account of visual inefficiency, are not able to take advantage of the educational system or to fit normally into our complex society. A successful reading program, however, does not depend upon the educator alone. He must have the active co-operation of the parents and various specialists—the eye specialist, the psychologist, the research worker, and the physician. The methods of approach to the study and correction of reading deficiencies by the teacher and the various specialists may be different, because of the differences in their training, but the fact that psychological as well as physiological factors are often involved in a case of reading disability makes their combined efforts essential in a comprehensive reading program.

Many of the recent studies in reading have emphasized remedial work rather than elaborate diagnostic techniques, but it is obvious to anyone familiar with developments in this field that remedial work alone, independent of preventive measures, does not solve the problem. The teacher of reading must have at her command a tangible technique, adapted to classroom use, which provides not only for diagnostic, prognostic, and remedial measures, but for the effective first teaching of this subject.

This book is written in response to numerous

requests from many sources for information concerning the teaching, diagnostic, and remedial reading techniques herein described. As the developmental work in connection with these techniques progressed, various phases were dealt with in formal reports, supported by statistical data, but publication has been withheld until the underlying theories and suggested procedures could be tested over a period of time in practical classroom and office situations. During the experimental period the *Ophthalm-O-Graph*, a portable, binocular eye-movement camera, and the *Metron-O-Scope*, a triple-shutter, short-exposure device, also have been developed. This apparatus, which is simple in operation and adapted to any classroom or office situation, has been designed (*a*) to provide objective information regarding the actual reading performance and (*b*) to carry on effectively controlled reading. The reading techniques and the apparatus have been used successfully by numerous educators and eye specialists for more than two years, and it is now desirable that they be described.

Part I presents photographs of the pioneers in reading research and lists of their published contributions in this field. Part II contains pictures and diagrams of the greater part of the apparatus which has been developed for obtaining objective information concerning eye behavior in reading by means of eye-movement photography, includ-

ing the portable, binocular eye-movement camera. The extent of the developmental work in the field of eye-movement photography is an indication of the importance of this phase of educational research. Some of the information used has appeared in other publications, but this is the first attempt to assemble the material in historical sequence. Part III describes the experimental work in connection with the Metron-O-Scope and presents briefly some of the essentials of a comprehensive reading program. Part IV contains experimental data relating to two special techniques known as controlled reading.

The research reported in this book has included the following activities: (*a*) consulting the majority of the references in the field of reading (of which there are some fifteen hundred), as well as the literature in the fields of ophthalmology and optometry relating to this subject; (*b*) photographing the eye-movements of some twenty-five hundred subjects, ranging from first-grade pupils to adults in the sixties; and (*c*) visiting all the educational institutions in the United States where outstanding work in reading research has been carried on. In this nation-wide survey of orthoptic and remedial reading work over one hundred leaders in education, ophthalmology, and optometry have been interviewed, and in all instances the co-operation of these men and women has been most gratifying. An excellent

picture of the present status of reading research has been obtained, and, naturally, the presentation of this material has been influenced somewhat by the information given and the opinions expressed in these interviews.

Special mention should be made of the following, who have contributed pictures or information concerning research in the field of reading; who have helped with suggestions in regard to the manuscript and statistical data; or who have given valuable information based on their experience in orthoptic work. They are not to be held responsible, however, for any of the statements made or the theories advanced.

Frank J. Adams, Ph.D., Associate Professor of Educational Psychology, University of Texas, Austin, Texas

M. H. Allen, O.D., Corpus Christi, Texas

T. J. Arneson, O.D., Minneapolis, Minnesota.

Thomas G. Atkinson, M.D., Professor, Northern Illinois College of Optometry, Chicago, Illinois

Miss Edith M. Baker, Acting Librarian, Clark University, Worcester, Massachusetts

Mrs. Hattie Price Baker, M.A., Assistant Professor of Education and Director of Visual Instruction, Howard Payne College, Brownwood, Texas

Robert J. Beitel, Jr., Ph.D., Bureau of Visual Science, American Optical Company, Southbridge, Massachusetts

Emmett Albert Betts, Ph.D., Director of Teacher Education, State Normal School, Oswego, New York

Paul A. K. Boeder, Ph.D., Bureau of Visual Science, American Optical Company, Southbridge, Massachusetts

T. A. Brombach, O.D., San Francisco, California

Guy T. Buswell, Ph.D., Professor of Educational Psychology, University of Chicago, Chicago, Illinois

James McKeen Cattell, Ph.D., Editor, New York City

Brant Clark, Ph.D., Lecturer in Psychology, University of Southern California, Los Angeles, California

Forrest D. Comfort, A.M., Lecturer in Education, Harvard University, Cambridge, Massachusetts

George Crow, O.D., Los Angeles, California

Walter F. Dearborn, Ph.D., M.D., Professor of Education and Director of the Psycho-Educational Clinic of the Graduate School of Education, Harvard University, Cambridge, Massachusetts

Miss Gertrude Dobson, Bureau of Visual Science, American Optical Company, Southbridge, Massachusetts

Raymond Dodge, Ph.D., Professor Emeritus of Psychology, Institute of Human Relations, Yale University, New Haven, Connecticut

P. J. Dodson, M.A., Superintendent of Schools, Bastrop, Texas

R. A. Ellis, O.D., Brownwood, Texas

Miss Louise Farwell, Ph.D., Director of Research, National College of Education, Evanston, Illinois

Miss Grace M. Fernald, Ph.D., Associate Professor of Psychology, University of Southern California at Los Angeles, Los Angeles, California

Adelbert Ford, Ph.D., Professor of Psychology, Lehigh University, Bethlehem, Pennsylvania

Arthur I. Gates, Ph.D., Professor of Educational Psychology, Columbia University, New York City

H. H. Gerdes, O.D., Waco, Texas

Sanford R. Gifford, M.D., Professor of Ophthalmology and Head, Department of Ophthalmology, Northwestern University Medical School, Chicago, Illinois

Clarence T. Gray, Ph.D., Professor of Educational Psychology and Head, Department of Educational Psychology, University of Texas, Austin, Texas

William S. Gray, Ph.D., Professor of Education, University of Chicago, Chicago, Illinois

Nelson Greeman, O.D., San Antonio, Texas

George P. Guibor, M.D., Instructor in Ophthalmology, Northwestern University Medical School, Chicago, Illinois

J. P. Guilford, Ph.D., Professor of Psychology, University of Nebraska, Lincoln, Nebraska

LeGrand H. Hardy, M.D., New York City

Harry Helson, Ph.D., Associate Professor of Psychology, Bryn Mawr College, Bryn Mawr, Pennsylvania

Avery M. Hicks, M.D., San Francisco, California

B. F. Holland, Ph.D., Adjunct Professor of Educational Psychology, University of Texas, Austin, Texas

George N. Horsford, M.D., San Francisco, California

Elmer Hotaling, O.D., New York City

Charles H. Judd, Ph.D., Charles F. Grey Distinguished Service Professor of Education and Head, Department of Education, University of Chicago, Chicago, Illinois

Walter F. Kimball, O.D., St. Joseph, Missouri

A. Edward Lamb, B.A., Reading Supervisor, Brownwood Public Schools, Brownwood, Texas

James E. Lebensohn, M.D., Instructor in Ophthalmology, Northwestern University Medical School, Chicago, Illinois

C. C. Mason, Ph.D., North Texas Agricultural College, Arlington, Texas

Walter R. Miles, Ph.D., Professor of Psychology, Yale University, and Attending Psychologist, New Haven Hospital and Dispensary, New Haven, Connecticut

Lloyd Mills, M.D., Los Angeles, California

John F. Morrow, O.D., Bureau of Visual Science, American Optical Company, Southbridge, Massachusetts

Carl Murchison, Ph.D., Professor of Psychology, Director of Psychological Laboratories and of the University Press, Clark University, Worcester, Massachusetts

Julius Neumueller, Director, Bureau of Visual Science, American Optical Company, Southbridge, Massachusetts

George E. Park, M.D., Clinical Assistant, Department of Ophthalmology, Northwestern University Medical School, Chicago, Illinois

Harry E. Pine, O.D., Chicago, Illinois

Jesse D. Reynolds, M.A., Graduate Student, Department of Educational Psychology, University of Texas, Austin, Texas

J. G. Shelton, O.D., President, Texas Optometric Association, Austin, Texas

Miss Mildred Smith, Wilmer Ophthalmological Institute, Johns Hopkins Medical School, Baltimore, Maryland

Millard F. Swartz, O.D., Lubbock, Texas

Edward L. Thorndike, Ph.D., Professor of Education and Director, Division of Psychology, Institute of Educational Research, Columbia University, New York City

Miles A. Tinker, Ph.D., Associate Professor of Psychology, University of Minnesota, Minneapolis, Minnesota

Roland C. Travis, Ph.D., Associate Professor of Psychology, Western Reserve University, Cleveland, Ohio

Frederick H. Verhoeff, M.D., Professor of Ophthalmic Research and Director, Howe Laboratory of Ophthalmology, Harvard University, Cambridge, Massachusetts

Miss M. D. Vernon, M.A., Psychological Laboratory, University of Cambridge, Cambridge, England

Albert Walton, Ph.D., Instructor in Psychology, Stanford University, Stanford University, California

William E. Walton, Ph.D., Assistant Professor of Psychology, University of Nebraska, Lincoln, Nebraska

Homer E. Weaver, Ph.D., Assistant Professor of Psychology, Oberlin College, Oberlin, Ohio

Gerald A. Yoakam, Ph.D., Professor of Education and Director of Research and Courses in Elementary Education, University of Pittsburgh, Pittsburgh, Pennsylvania

Much of the experimental data for this study was gathered in the public schools of Austin, Texas, and the successful completion of this preliminary work was due in a large measure to the unfailing co-operation of A. N. McCallum, Superintendent of Schools, and George H. Wells, principal of the Austin High School. A debt of gratitude is due James Y. Taylor of the American

Optical Company, Southbridge, Massachusetts, and Carl C. Taylor of Educational Laboratories, Inc., Brownwood, Texas, who were primarily responsible for designing and building the Ophthalm-O-Graph and the Metron-O-Scope; and to Mr. Douglas Coalson of Walker-Smith Company, Brownwood, Texas, and the American Optical Company, Southbridge, Massachusetts, whose generous support has made possible the development of these instruments.

TABLE OF CONTENTS

PART IV. EXPERIMENTAL STUDIES RELATING TO CONTROLLED READING

LIST OF PLATES

LIST OF TABLES

PART I

SOME OF THE LEADERS IN READING RESEARCH AND EYE-MOVEMENT PHOTOGRAPHY

CHAPTER I

PERSONAL FACTS CONCERNING THE LEADERS IN RESEARCH

The material in this chapter indicates that interest in reading research has increased from year to year, especially in the last decade; that the experimental work has not been confined to any one country, state, or institution; and that those engaged in it are individuals with diverse interests. Many of them have made distinct contributions to other phases of educational work, but no attempt is made to include material that does not bear directly on eye-movement photography and other phases of reading research. In a few cases, where the photograph of an individual is not available at this time, the list of contributions also is omitted but the most important works are included in the General Bibliography.[1] As it would be impossible to rank or classify those whose work is mentioned, the photographs are arranged in alphabetical order. With the pertinent facts concerning the training and activities of each individual before him the reader is better

[1] The references, both in the general and in the individual lists, have been checked carefully with the original publications to secure accuracy of detail necessary in locating them.

able to appreciate the amount of thought and effort that has gone into the development of the reading methods and techniques used at present in the classroom and the laboratory.

It would not be possible to present in detail a comprehensive view of the field of reading research at this time, but there are evidences of decided departures from accepted theories of teaching reading. Experimental work along new lines is being carried on vigorously in many outstanding educational institutions, and as new techniques and apparatus are developed, even more sweeping changes may be expected. The fact that the photographs in Part I represent a selected group does not imply that others have not done, and are not doing, valuable work. To keep the volume within limits, only those who made the first contributions and those who later have made intensive studies of particular phases of the reading problem are included.

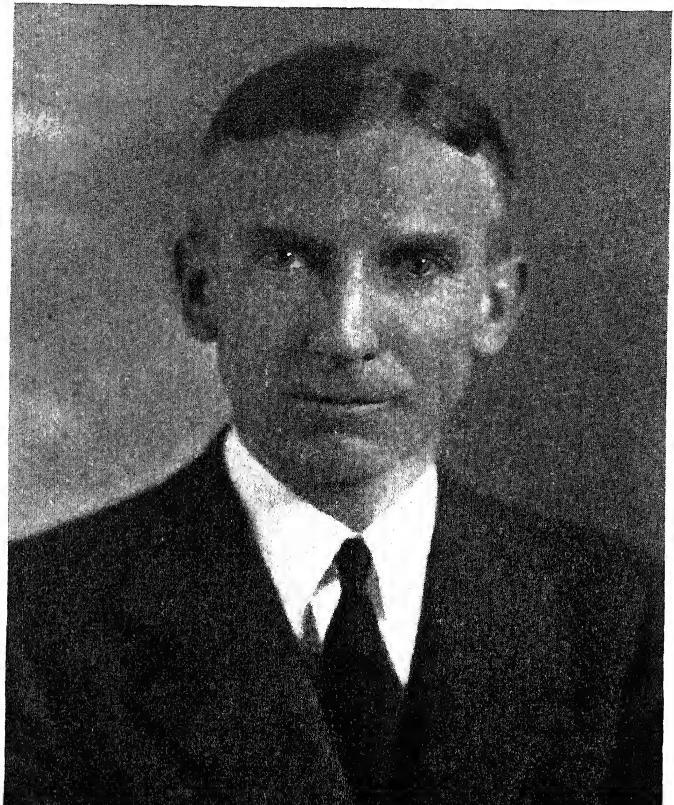
PUBLICATIONS RELATING TO RESEARCH IN READING AND EYE-MOVEMENT PHOTOGRAPHY

Dr. Guy T. Buswell

An Experimental Study of the Eye-Voice Span in Reading. Supplementary Educational Monographs, No. 17. Chicago: University of Chicago, 1920. Pp. xii+106.

"The Relationship between Eye-Perception and Voice-Response in Reading," *Journal of Educational Psychology*, XII (April, 1921), 217–27.

PLATE I



GUY THOMAS BUSWELL, PH.D.

Professor of Educational Psychology, University of Chicago, Chicago, Illinois. Born January 21, 1891; A.B., York College, 1913; A.M., Chicago, 1916; Ph.D., Chicago, 1920; research in reading and eye-movement photography, University of Chicago.

Fundamental Reading Habits: A Study of Their Development. Supplementary Educational Monographs, No. 21. Chicago: University of Chicago, 1922. Pp. xiv+150.

With CHARLES H. JUDD. *Silent Reading: A Study of the Various Types.* Supplementary Educational Monographs, No. 23. Chicago: University of Chicago, 1922. Pp. xiv+160.

With LENORE JOHN. *Diagnostic Studies in Arithmetic.* Supplementary Educational Monographs, No. 30. Chicago: University of Chicago, 1926. Pp. xiii+212.

"The Place of Oral Reading in the Elementary School," *Improvement in the Teaching of Reading*, pp. 60–62. Bureau of Research Monograph, No. 1. Baltimore, Md.: Baltimore Department of Education, 1926. Pp. 129.

A Laboratory Study of the Reading of Modern Foreign Languages. New York: Macmillan Co., 1927. Pp. xii+100.

With LEONORE JOHN. *The Vocabulary of Arithmetic.* Supplementary Educational Monographs, No. 38. Chicago: University of Chicago, 1931. Pp. xi+146.

"Photographing Eye-Movements in Reading," *Educational Focus*, III (September, 1932), 8–11. Rochester, N.Y.: Bausch & Lomb Optical Co.

How People Look at Pictures: A Study of the Psychology of Perception in Art. Chicago: University of Chicago Press, 1935. Pp. xv+198.

DR. JAMES MCKEEN CATTELL

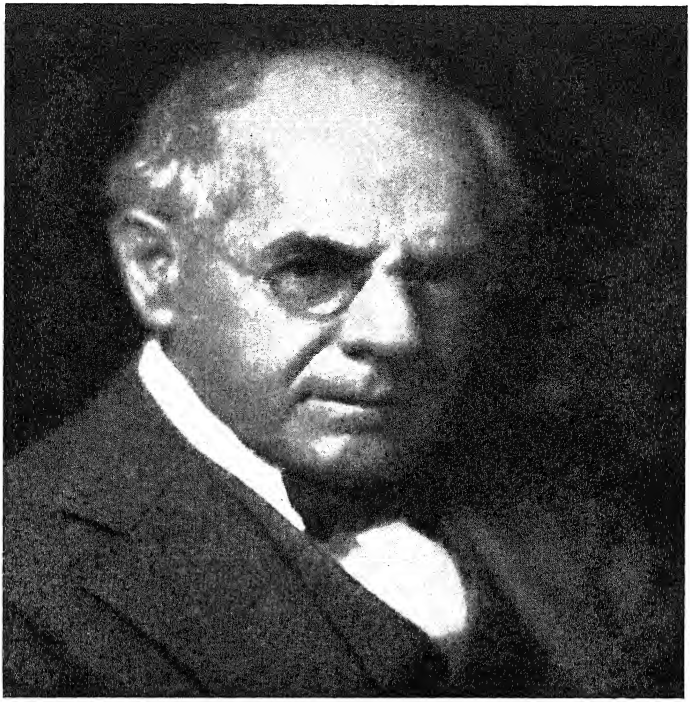
"Über die Zeit der Erkennung und Benennung von Schriftzeichen, Bildern, und Farben," *Philosophische Studien*, II (1885), 635–50. Published in abstract: "The Time It Takes To See and Name Objects," *Mind*, XI (January, 1886), 63–65.

"Über die Trägheit der Netzhaut und des Sehcentrums," *Philosophische Studien*, III (1886), 94–127. Published in abstract: "The Inertia of the Eye and Brain," *Brain*, VIII (October, 1885), 295–312.

"The Influence of the Intensity of the Stimulus on the Length of the Reaction Time," *Brain*, VIII (January, 1886), 51–216.

"Psychometrische Untersuchungen," *Philosophische Studien*, III (1886), 1–72, 305–35, 452–92. Published, in part, as "The Time Taken Up by Cerebral Operations," *Mind*, XI (April, July, October, 1886), 220–42, 377–89, 524–38.

PLATE II



JAMES McKEEN CATTELL, PH.D.

Editor, New York City. Born May 25, 1860; A.B., Lafayette, 1880; A.M., Lafayette, 1883; Ph.D., Leipzig, 1886; reading research, University of Leipzig, Columbia University.

"Aufmerksamkeit und Reaction," *Philosophische Studien*, VIII (1893), 403–6.

"On Relations of Time and Space in Vision," *Psychological Review*, VII (July, 1900), 325–43.

"Vision with the Moving Eye," *ibid.*, VII (September, 1900), 507–8.

The Psychological Researches of James McKeen Cattell. A Review by Some of His Pupils. "Columbia Contributions to Philosophy and Psychology, Vol. XXII, No. 4. (Also listed as Archives of Psychology, No. 30, April, 1914.) New York: Columbia University, 1914. Pp. 102.

Dr. Walter F. Dearborn

"Retinal Local Signs," *Psychological Review*, XI (July, 1904), 297–307.

The Psychology of Reading. Columbia University Contributions to Philosophy, Psychology and Education, Vol. XIV, No. 1. (Also Archives of Philosophy, Psychology and Scientific Method, No. 4.) New York: Columbia University, 1906. Pp. 134.

"Professor Cattell's Studies in Reading and Perception," *The Psychological Researches of James McKeen Cattell: A Review by Some of His Pupils.* Columbia Contributions to Philosophy and Psychology, Vol. XXII, No. 4. (Also Archives of Psychology, No. 30 [April, 1914], pp. 34–45.) New York: Columbia University, 1914.

With H. A. Langfeld. "Portable Tachistoscope and Memory Apparatus," *Psychological Review*, XXIII (September, 1916), 385–89.

"Teaching Reading to Non-readers," *Elementary School Journal*, XXX (December, 1929), 266–70.

"The Nature of Special Abilities and Disabilities," *School and Society*, XXXI (May 10, 1930), 632–36.

"Ocular and Manual Dominance in Dyslexia," *Psychological Bulletin*, XXVIII (November, 1931), 704. Proceedings of the Thirty-ninth Annual Meeting of the American Psychological Association, Inc., 1931.

"Structural Factors Which Condition Special Disability in Reading," *Proceedings and Addresses of the Fifty-seventh Annual Session of the American Association on Mental Deficiency* (May

PLATE III

WALTER FENNO DEARBORN, PH.D., M.D.

Professor of Education and Director, Psycho-educational Clinic of the Graduate School of Education, Harvard University, Cambridge, Massachusetts. Born July 18, 1878; A.B., Wesleyan, 1900; A.M., Wesleyan, 1903; Ph.D., Columbia, 1905; M.D., Munich, 1913; research in reading and eye-movement photography, Wesleyan University, Columbia University, University of Wisconsin, University of Chicago, Harvard University.

29–June 3, 1933), XXXVIII, 268–83. Godfrey, Ill.: Groves B. Smith, Secretary (Beverly Farm, Inc.).

With FORREST D. COMFORT. "Differences in the Size and Shape of Ocular Images as Related to Defects in Reading." A preliminary report by the Psycho-educational Clinic of the Harvard Graduate School of Education. *Elementary English Review*, XII (May, 1935), 131–32.

DR. RAYMOND DODGE

"Beschreibung eines neuen Chronographen," *Zeitschrift für Psychologie und Physiologie der Sinnesorgane*, X (1896), 414–20.

BENNO ERDMANN and RAYMOND DODGE. *Psychologische Untersuchungen über das Lesen, auf experimenteller Grundlage.* Halle: Max Niemeyer, 1898. Pp. viii+360.

"The Reaction Time of the Eyes," *Psychological Review*, VI (September, 1899), 477–83.

"Visual Perception during Eye Movement," *ibid.*, VII (September, 1900), 454–65.

With T. S. CLINE. "The Angle Velocity of Eye Movements," *ibid.*, VIII (March, 1901), 145–57.

"The Act of Vision," *Harpers Monthly Magazine*, CIV (May, 1902), 937–41.

"Five Types of Eye Movement in the Horizontal Meridian Plane of the Field of Regard," *American Journal of Psychology*, VIII (January, 1903), 307–29.

"The Participation of the Eye Movements in the Visual Perception of Motion," *Psychological Review*, XI (January, 1904), 1–14.

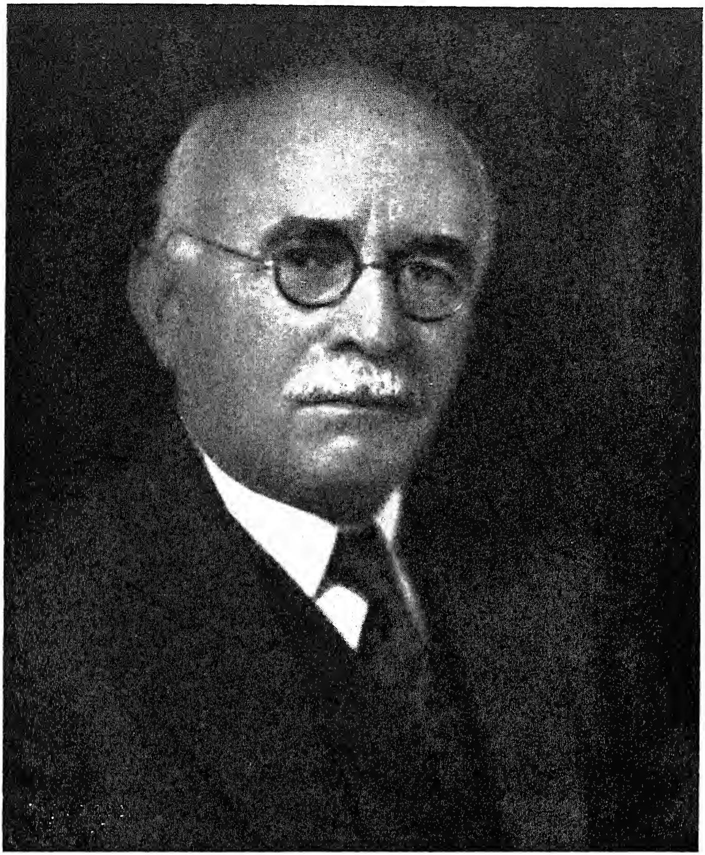
"The Illusion of Clear Vision during Eye Movement," *Psychological Bulletin*, II (June, 1905), 193–99.

"Recent Studies in the Correlation of Eye Movement and Visual Perception," *ibid.*, III (March, 1906), 85–92.

"An Improved Exposure Apparatus," *ibid.*, IV (January, 1907), 10–13.

An Experimental Study of Visual Fixation. Psychological Review Monograph Supplements, No. 35 (Vol. VIII, No. 4 [1907]). Pp. iv+96. (Trans. "Eine experimentelle Studie der visuellen Fixation," *Zeitschrift für Psychologie und Physiologie der Sinnesorgane*, LII [1909], 321–422).

PLATE IV



RAYMOND DODGE, PH.D.

Professor Emeritus of Psychology, Yale University, New Haven, Connecticut. Born February 20, 1871; A.B., Williams, 1893; Ph.D., Halle, 1896; research in reading and eye-movement photography, University of Halle (Prussia), Wesleyan University, Yale University, Nutrition Laboratory (Carnegie Institution of Washington), Boston, Massachusetts.

With Allan R. Diefendorf, M.D. "An Experimental Study of the Ocular Reactions of the Insane from Photographic Records," *Brain*, XXXI (November, 1908), 451–89.

With Allan R. Diefendorf, M.D. "An Analysis of the Involuntary Eye Movements in the Case of Congenital, Binocular, Lateral Nystagmus, from Photographic Records," *Archives of Ophthalmology*, XXXVIII (January, 1909), 1–7.

"Visual Motor Functions," *Psychological Bulletin*, VIII (November, 1911), 382–85. (Review of experimental work then in process in this field.)

With F. G. Benedict, M.D. "Neuro-Muscular Effects of Moderate Doses of Alcohol," *Proceedings National Academy of Sciences*, I (December, 1915), 605–8.

With F. G. Benedict, M.D. *Psychological Effects of Alcohol.* Carnegie Institution of Washington Publication, No. 232. Washington: Carnegie Institution of Washington, 1915. Pp. 281.

"Visual Motor Functions," *Psychological Bulletin*, XIII (November, 1916), 421–27. (Review of experimental work in the preceding five years.)

"The Psychology of Reading," *A Cyclopedia of Education*, edited by Paul Monroe, V, 115–18. New York: Macmillan Co., 1913.

"Visual Motor Functions," *Psychological Bulletin*, XVII (December, 1920), 418–20. (Review of experimental work in the preceding four years.)

"A Mirror-Recorder for Photographing the Compensatory Movements of Closed Eyes," *Journal of Experimental Psychology*, IV (June, 1921), 165–74.

"The Latent Time of Compensatory Eye Movements," *ibid.*, IV (August, 1921), 247–69.

"Habituation to Rotation," *ibid.*, VI (February, 1923), 1–35.

"Thresholds of Rotation," *ibid.*, VI (April, 1923), 107–37.

"Adequacy of Reflex Compensatory Eye Movements," *ibid.*, VI (June, 1923), 169–81.

Elementary Conditions of Human Variability. New York: Columbia University Press, 1927. Pp. 119.

With James C. Fox, Jr., M.D. "Optic Nystagmus, I: Technical Introduction," *Archives of Neurology and Psychiatry*, XX (October, 1928), 812–23.

With JAMES C. FOX, JR., M.D. "Optic Nystagmus, II: Variations in Nystagmographic Records of Eye Movements," *ibid.*, XXII (July, 1929), 55–74.

With ROLAND C. TRAVIS and JAMES C. FOX, JR., M.D. "Optic Nystagmus, III: Characteristics of the Slow Phase," *ibid.*, XXIV (July, 1930), 21–34.

"Fundamental Steps in the Development of Adaptive Behavior of the Eyes," *Journal of General Psychology*, IV (December, 1930), 3–14.

With JAMES C. FOX, JR., M.D., and FRANK H. COUCH, M.D. "Optic Nystagmus, IV: Psychological Conditions," *Archives of Neurology and Psychiatry*, XXVI (July, 1931), 23–35.

With WALTER R. MILES. "A Floating Mirror Technique for Recording Eye Movements," *American Journal of Psychology*, XLIII (January, 1931), 124–26.

Conditions and Consequences of Human Variability. New Haven: Yale University Press, 1931. Pp. x+162.

Autobiography of DR. RAYMOND DODGE. *A History of Psychology in Autobiography*, I, 99–121. International University Series in Psychology, edited by Carl Murchison. Worcester, Mass. Clark University Press, 1930.

DR. ARTHUR I. GATES

"An Experimental and Statistical Study of Reading and Reading Tests," *Journal of Educational Psychology*, XII (September, October, November, 1921), 303–14, 378–91, 445–64.

"A Study of Reading and Spelling with Special Reference to Disability," *Journal of Educational Research*, VI (June, 1922), 12–24.

The Psychology of Reading and Spelling with Special Reference to Disability. Columbia University Contributions to Education, No. 129. New York: Teachers College, Columbia University, 1922. Pp. v+108.

"Study of Depth and Rate of Comprehension in Reading by Means of a Practice Experiment," *Journal of Educational Research*, VII (January, 1923), 37–49.

With ELOISE BOEKER. "A Study of Initial Stages in Reading by Pre-school Children," *Teachers College Record*, XXIV (November, 1923), 469–88.

PLATE V

Arthur Irving Gates, Ph.D.

Professor of Educational Psychology, Columbia University, New York City. Born September 22, 1890; Litt.B., California, 1914; A.M., California, 1915; Ph.D., Columbia, 1917; reading research, Columbia University.

With D. Van Alstyne. "The General and Specific Effects of Training in Reading, with Observations on the Experimental Technique," *ibid.*, XXV (March, 1924), 98–123.

"A Test of Ability in the Pronunciation of Words," *ibid.*, XXVI (November, 1924), 205–19.

With E. Hemke and D. Van Alstyne. "Problems in Beginning Reading," *ibid.*, XXVI (March, 1925), 572–91.

"The Supplementary Device versus the Intrinsic Method of Teaching Reading," *Elementary School Journal*, XXV (June, 1925), 775–86.

"Functions of Flash-Card Exercises in Reading," *Teachers College Record*, XXVII (December, 1925), 311–26.

"Measurement, Diagnosis and Remedial Treatment in Reading," *Improvement in the Teaching of Reading*, pp. 49–54. Bureau of Research Monograph, No. 1. Baltimore, Md.: Baltimore Department of Education, 1926. Pp. 129.

"The Construction of a Reading Vocabulary for the Primary Grades," *Teachers College Record*, XXVII (March, 1926), 625–42.

"Measurement and Diagnosis in Reading and Spelling," *Thirteenth Annual Schoolmen's Week Proceedings* (March 24–27, 1926), pp. 376–83. Philadelphia: Press of the University of Pennsylvania, 1926.

"Methods and Theories of Teaching Reading Tested by Studies of Deaf Children," *Journal of Educational Research*, XIV (June, 1926), 21–32.

"An Experimental Study of Teaching the Deaf to Read," *Volta Review*, XXVIII (June, 1926), 295–98.

"A Series of Tests for the Measurement and Diagnosis of Reading Ability in Grades 3 to 8," *Teachers College Record*, XXVIII (September, 1926), 1–23.

Gates Silent Reading Tests, Primary Series, Types 1, 2, and 3. New York: Teachers College, Columbia University, 1926.

Gates Silent Reading Tests, Grades 3 to 8 Series, Types A, B, C, and D. New York: Teachers College, Columbia University, 1926.

"The Gates Primary Reading Tests," *Teachers College Record*, XXVIII (October, 1926), 146–78.

"A Study of the Rôle of Visual Perception, Intelligence and Certain Associative Processes in Reading and Spelling," *Journal of Educational Psychology*, XVII (October, 1926), 433–35.

"Studies of Phonetic Training in Beginning Reading," *ibid.*, XVIII (April, 1927), 217–26.

"Methods of Constructing and Validating the Gates Reading Tests," *Teachers College Record*, XXIX (November, 1927), 148–59.

"The Development of Independence in Word Recognition," *Elementary English Review*, V (April, 1928), 113–15.

"Methods of Developing Accuracy, Fluency, and Fulness of Comprehension in Reading," *Child Education*, V (September and October, 1928), 415–16, 496–97.

"Methods of Securing Word Mastery Skills," *ibid.*, V (November, 1928), 551, 582.

"The Selection of Words and Word Elements," *ibid.*, V (December, 1928), 625, 648.

"Adjusting the Reading Course to Individual Differences as a Means of Cultivating Literary Appreciation," *Individual Instruction*, I (December, 1928), 37–39.

New Methods in Primary Reading. New York: Teachers College, Columbia University, 1928. Pp. ix+236.

"New Types of Printed Materials for Teaching Reading," *Proceedings of the Ninth Annual Session of the Ohio State Educational Conference*. Ohio State University Bulletin, XXXIV (September, 1929), 539–50.

"Selection and Organization of Reading Selections," *Child Education*, VI (January, 1929), 9.

"Selections and Organization of Reading Materials," *ibid.*, VI (February, 1929), 94.

"Diagnostic and Remedial Methods," *ibid.*, VI (March, 1929), 158, 160.

"New Material for Reading," *Chicago Schools Journal*, XII (March, 1930), 273–78.

"The Intrinsic Method of Developing a Reading Vocabulary," *Modern Education*, III (October, 1930), 2–6, 42.

"An Intrinsic Method of Developing Independent Ability in Word Recognition in Reading," *ibid.*, III (December, 1930), 2–5, 42–43.

"Characteristics and Uses of Practice Exercises in Reading," *Teachers College Record*, XXXII (December, 1930), 221–35.

Interest and Ability in Reading. New York: Macmillan Co., 1930. Pp. xii+264.

"An Intrinsic Method in Reading," *Educational Outlook*, V (January, 1931), 105–14.

"What Do We Know about Optimum Length of Lines in Reading?" *Journal of Educational Research*, XXIII (January, 1931), 1–7.

"Organization and Incentives in Reading," *Modern Education*, III (February, 1931), 3–4, 38–41.

"Diagnosis and Measurement of Reading Ability by Intrinsic Methods," *ibid.*, III (April, 1931), 2–3, 42–46.

"New Ways of Teaching Reading," *Parents Magazine*, VI (April, 1931), 18–19, 52–55.

Reading for Public School Administrators. New York: Teachers College, Columbia University, 1931. Pp. vi+126.

With C. C. Peardon and I. C. Sartorius. "Studies of Children's Interests in Reading," *Elementary School Journal*, XXXI (May, 1931), 656–70.

Gates Primary Reading Test, Type 2. New York: Teachers College, Columbia University, 1931 (rev.).

"The Child's Reading Steps Made Easier," *New York Times*, III (Sunday, March 27, 1932), 7:3.

With C. C. Peardon. *Gates-Peardon Practice Exercises in Reading, Grades 3 to 6*, Types A, B, C, and D. New York: Teachers College, Columbia University, 1932.

Tests of Word Recognition Techniques. New York: Teachers College, Columbia University, 1932. Pp. 4.

Manual of Directions for Gates Primary Reading Tests. New York: Teachers College, Columbia University, 1931 (rev.).

With C. C. Bennett. *Reversal Tendencies in Reading: Causes, Diagnosis, Prevention, and Correction* New York: Teachers College, Columbia University, 1933. Pp. 33.

Gates Reading Diagnosis Tests. New York: Teachers College, Columbia University, 1933 (rev.).

Gates Record Booklet for Reading Diagnosis Tests. New York: Teachers College, Columbia University, 1933 (rev.).

Manual of Directions for Gates Silent Reading Tests, Grades 3 to 8. New York: Teachers College, Columbia University, 1934 (rev.).

With OTHERS. *Special Methods and Psychology of the Elementary School Subjects*, pp. 54–69, 111–14. Review of Educational Research, Vol. V, No. 1. Washington: American Educational Research Association of the National Education Association, 1935.

"Viewpoints Underlying the Study of Reading Disabilities," *Elementary English Review*, XII (April, 1935), 85–90, 105.

A Reading Vocabulary for the Primary Grades. New York: Teachers College, Columbia University, 1935 (rev.). Pp. 32.

"Recent Developments in Diagnostic and Remedial Teaching in Reading," *The Application of Research Findings to Current Educational Practices*, pp. 83–91. Official Report of American Educational Research Association, 1935. Washington: American Educational Research Association of the National Education Association.

The Improvement of Reading. New York: Macmillan Co., 1935 (rev.). Pp. xvi+668.

With GUY L. BOND. "Reading Investigations at Teachers College," *Journal of Educational Research*, XXIX (February, 1936), 466–72.

DR. CLARENCE T. GRAY

"The Relation of Breathing to Oral Reading," *Journal of Educational Psychology*, IV (January, 1913), 39–41.

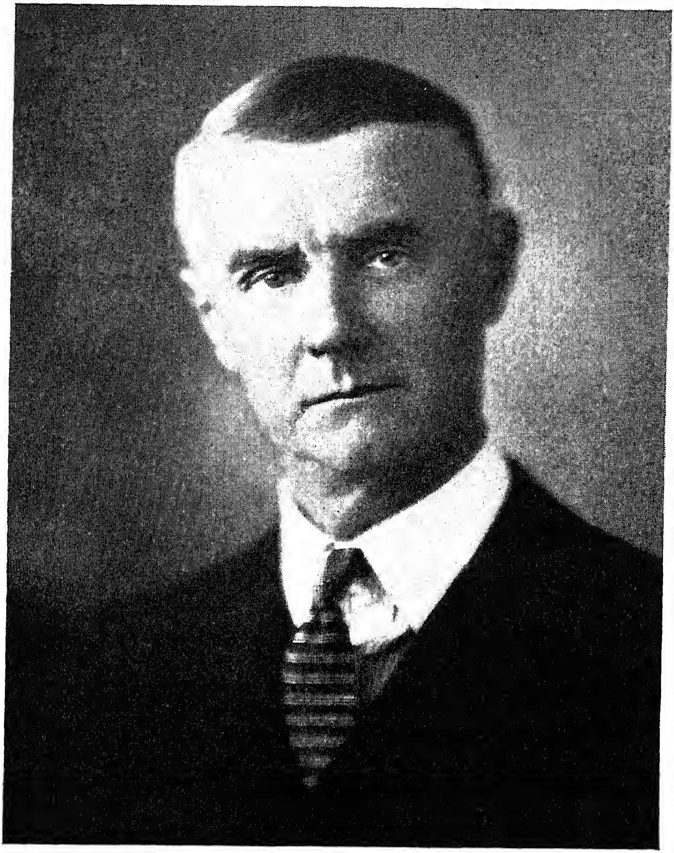
Types of Reading Ability as Exhibited through Tests and Laboratory Experiments. Supplementary Educational Monographs, No. 5. Chicago: University of Chicago, 1917. Pp. xiii+196.

With S. McG. LLOYD. *Reading in a Texas City.* University of Texas Bulletin No. 1853, September 20, 1918: Educational Series, No. 4. Austin, Tex.: University of Texas, 1920. Pp. vi+107.

Deficiencies in Reading Ability—Their Diagnosis and Remedies. New York: D. C. Heath & Co., 1922. Pp. xiv+420.

"The Anticipation of Meaning as a Factor in Reading Ability," *Elementary School Journal*, XXIII (April, 1923), 614–26.

PLATE VI



Clarence Truman Gray, Ph.D.

Professor of Educational Psychology, and Head, Department of Educational Psychology, University of Texas, Austin, Texas. Born November 22, 1877; A.B., Indiana, 1904; A.M., Chicago, 1911; Ph.D., Chicago, 1916; research in reading and eye-movement photography, University of Chicago, University of Texas.

The Status of Reading in the Fourth, Fifth, Sixth and Seventh Upper Grades of the Public Schools of Texas. Texas Educational Survey Report, V, Part III, 413–43. Austin, Tex.: Texas Educational Survey Commission, 1924.

"A Comparison of Two Types of Silent Reading as Used by Children in Different School Grades," *Journal of Educational Psychology*, XX (March, 1929), 169–76.

Workaday Readers and *Teachers' Manuals for Workaday Readers*, Grades 4, 5, and 6. New York: D. C. Heath & Co., 1929.

"The Purposes and Values of Oral Reading in the Intermediate and Upper Grades of the Elementary Schools," *Elementary School Journal*, XXIX (January, 1929), 335–43.

"Reading in the Junior High School," *Educational Outlook*, VI (November, 1931), 46–51.

DR. WILLIAM S. GRAY

"Selected Bibliography upon Tests of Reading Ability," *Essentials in Elementary School Subjects: Minimum Standards and Current Practices*, pp. 59–60. Fourteenth Yearbook of the National Society for the Study of Education, Part I. Bloomington, Ill.: Public School Publishing Co., 1916.

"Reading," *School Survey, Grand Rapids, Michigan*, chap. iv. Grand Rapids, Mich.: Board of Education, 1916.

"Methods of Teaching Reading, I and II," *Elementary School Journal*, XVI (January and February, 1916), 231–46, 281–98.

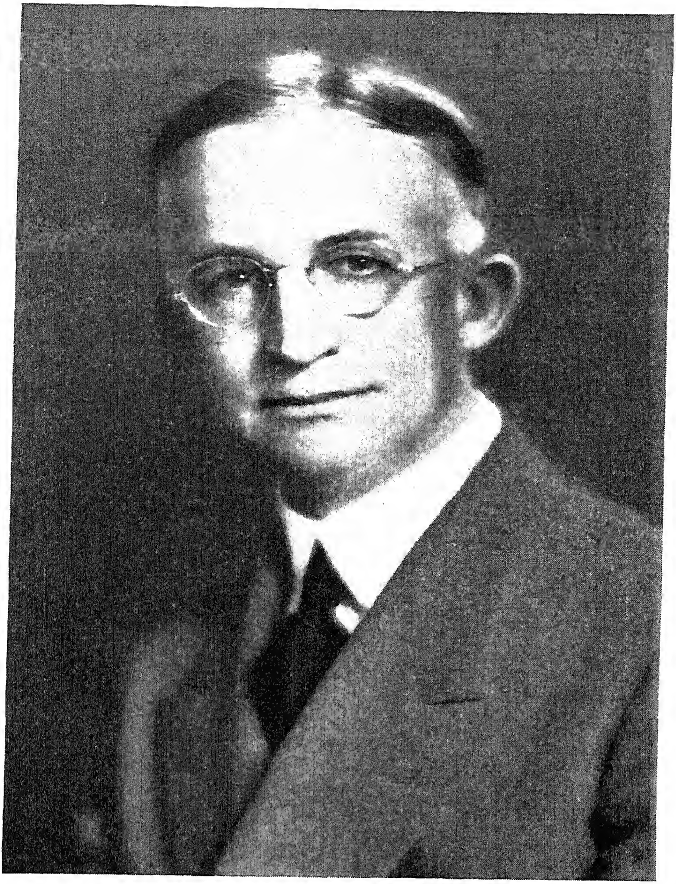
"A Study of the Emphasis on Various Phases of Reading Instruction in Two Cities," *ibid.*, XVII (November, 1916), 178–86.

"A Co-operative Study of Reading in Eleven Cities of Northern Illinois," *ibid.*, XVII (December, 1916), 250–65.

"The Relation of Silent Reading to Economy in Education," *Second Report of the Committee on Minimum Essentials in Elementary-School Subjects*, pp. 17–32. Sixteenth Yearbook of the National Society for the Study of Education, Part I. Bloomington, Ill.: Public School Publishing Co., 1917.

Studies of Elementary-School Reading through Standardized Tests. Supplementary Educational Monographs, No. 1. Chicago: University of Chicago, 1917. Pp. viii+157.

PLATE VII



William Scott Gray, Ph.D.

Professor of Education, University of Chicago, Chicago, Illinois. Born June 5, 1885; B.S., Chicago, 1913; A.M., Columbia, 1914; Ph.D., Chicago, 1916; research in reading and eye-movement photography, University of Chicago.

"Educational Writings, I. Descriptive List of Standard Tests, 1917," *Elementary School Journal*, XVIII (September, 1917), 56–70.

"Reading," *Survey of the St. Louis Public Schools*, chap. xii. Yonkers-on-Hudson, New York: World Book Co., 1918.

"The Use of Tests in Improving Education," *Elementary School Journal*, XIX (October, 1918), 121–42.

"Principles of Method in Teaching Reading as Derived from Scientific Investigations," *Fourth Report of the Committee on Economy of Time in Education*, pp. 26–51. Eighteenth Yearbook of the National Society for the Study of Education, Part II. Bloomington, Ill.: Public School Publishing Co., 1919.

"The Relation between Study and Reading," *Addresses and Proceedings of the Fifty-seventh Annual Meeting of the National Education Association*, LVII (1919), 580–86. Washington: National Education Association, 1919.

"Reading in the Elementary Schools of Indianapolis," *Elementary School Journal*, XIX (January, February, March, April, 1919), 336–53, 419–44, 506–31, 608–27.

"Value of Informal Tests of Reading Accomplishment," *Journal of Educational Research*, I (February, 1920), 103–11.

"Individual Difficulties in Silent Reading in the Fourth, Fifth and Sixth Grades," *Report of the Society's Committee on Silent Reading*, pp. 39–52. Twentieth Yearbook of the National Society for the Study of Education, Part II. Bloomington, Ill.: Public School Publishing Co., 1921.

"The Diagnostic Study of an Individual Case in Reading," *Elementary School Journal*, XXI (April, 1921), 577–94.

"Diagnostic and Remedial Steps in Reading," *Journal of Educational Research*, IV (June, 1921), 1–15.

With DELIA KIBBE, LAURA LUCAS, and LAWRENCE W. MILLER *Remedial Cases in Reading: Their Diagnosis and Treatment*. Supplementary Educational Monographs, No. 22. Chicago: University of Chicago, 1922. Pp. viii+208.

"The Technique of Diagnosing Individual Cases in Reading," *Ninth Annual Conference on Educational Measurements*. Bulletin of the Extension Division, Indiana University, VII (August, 1922), 16–25.

"Types of Remedial Cases," *ibid.*, pp. 26–35.

"Remedial Measures in Reading," *ibid.*, pp. 36–42.

"The Importance of Intelligent Silent Reading," *Elementary School Journal*, XXIV (January, 1924), 348–56.

"Case Studies of Reading Deficiencies in Junior High School," *Journal of Educational Research*, X (September, 1924), 132–40.

Summary of Investigations Relating to Reading. Supplementary Educational Monographs, No. 28. Chicago: University of Chicago, 1925. Pp. vii+275.

"Summary of Reading Investigations" (July 1, 1924—June 30, 1925), *Elementary School Journal*, XXVI (February, March, April, May, 1926), 449–59, 507–18, 574–84, 662–73.

"Keynotes to Modern Requirements in the Teaching of Reading," *Improvement in the Teaching of Reading*, pp. 5–7. Bureau of Research Monograph, No. 1. Baltimore, Md.: Baltimore Department of Education, 1926. Pp. 129.

"Summary of Reading Investigations" (July 1, 1925—June 30, 1926), *Elementary School Journal*, XXVII (February and March, 1927), 456–66, 495–510.

With Laura Zirbes. "Primary Reading," *Classroom Teacher*, II, 39–386. Chicago: Classroom Teacher, Inc., 1927.

With Laura Zirbes. "Reading in the Intermediate Grades," *ibid.*, VI, 81–282. Chicago: Classroom Teacher, Inc., 1927.

"A Study of Ways and Means of Reorganizing and Improving Instruction in Reading," *Journal of Educational Research*, XV (March, 1927), 166–75.

"Summary of Reading Investigations" (July 1, 1926—June 30, 1927), *Elementary School Journal*, XXVIII (February, March, April, 1928), 443–59, 496–510, 587–602.

"Summary of Reading Investigations" (July 1, 1927—June 30, 1928), *ibid.*, XXIX (February and March, 1929), 443–57, 496–509.

With Ruth Monroe. *The Reading Interests and Habits of Adults.* New York: Macmillan Co., 1929. Pp. xiii+305.

"Summary of Reading Investigations" (July 1, 1928—June 30, 1929), *Elementary School Journal*, XXX (February and March, 1930), 450–66, 496–508.

"The Importance of Intelligent Reading and of Library Facilities," *University of North Carolina Extension Bulletin*, X (December, 1930), 30–39.

"Notable Reforms in Teaching Reading," *Journal of the National Education Association*, XIX (December, 1930), 287–88.

"Reading as a School Subject," *ibid.*, XX (January, 1931), 37–38.

"Guidance in Reading," *ibid.*, XX (February, 1931), 53–54.

"Enjoyment of Good Literature," *ibid.*, XX (March, 1931), 89–90.

"Summary of Reading Investigations" (July 1, 1929—June 30, 1930), *Elementary School Journal*, XXXI (March and April, 1931), 531–46, 592–606.

"Permanent Interest in Reading," *Journal of the National Education Association*, XX (April, 1931), 137–38.

"Remedial Cases in Reading," *ibid.*, XX (May, 1931), 163–64.

"Reading Deficiencies in Secondary Schools," *ibid.*, XX (June, 1931), 197–98.

"Reading," *Special Methods in the Elementary School.* Review of Educational Research, I, No. 4, 247–60. Washington: American Educational Research Association of the National Education Association, 1931.

"Reading," *Psychology of the School Subjects.* Review of Educational Research, I, No. 5, 328–36. Washington: American Educational Research Association of the National Education Association, 1931.

With Wil Lou Gray and J. Warren Tilton. *The Opportunity Schools of South Carolina: An Experimental Study.* New York: American Association for Adult Education, 1932. Pp. 142.

"Reading and Literature," *Special Methods on the High School Level.* Review of Educational Research, II, No. 1, 29–34. Washington: American Educational Research Association of the National Education Association, 1932.

"Provision for Individual Differences in Reading Efficiency," *Provision for the Individual in College Education.* Proceedings of the Institute for Administrative Officers of Higher Institutions, IV, 144–58. Chicago: University of Chicago Press, 1932.

"Summary of Reading Investigations" (July 1, 1930—June 30, 1931), *Elementary School Journal*, XXXII (February, March, April, 1932), 447–63, 510–20, 587–94.

"Fundamentals in Silent Reading," *Elementary English Review*, IX (April, 1932), 95–98.

"Why Children Fail in Reading," *Understanding the Child*, I–III (October, 1932), 16–18.

With GERTRUDE WHIPPLE. *Improving Instruction in Reading: An Experimental Study*. Supplementary Educational Monographs, No. 40. Chicago: University of Chicago, 1933. Pp. xiii+226.

"Summary of Reading Investigations" (July 1, 1931—June 30, 1932), *Journal of Educational Research*, XXVI (February, 1933), 401–24.

"New Issues in Teaching Reading," *Elementary English Review*, X (September, 1933), 161–64, 182.

"Selected References on Elementary-School Instruction, Reading," *Elementary School Journal*, XXXIV (October, 1933), 130–34.

"Summary of Reading Investigations" (July 1, 1932—June 30, 1933), *Journal of Educational Research*, XXVII (April, 1934), 564–91.

"Curriculum Investigations at the Elementary and Secondary School Levels, A: Reading," *Review of Educational Research*, IV (April, 1934), 135–38.

"The Teaching of Silent Reading during the Next Decade," *Elementary English Review*, XI (April, 1934), 91–93, 118.

"Recent Reforms in Reading and Needed Expansion," *Texas Outlook*, XVIII (May and June, 1934), 34–36, 50–52.

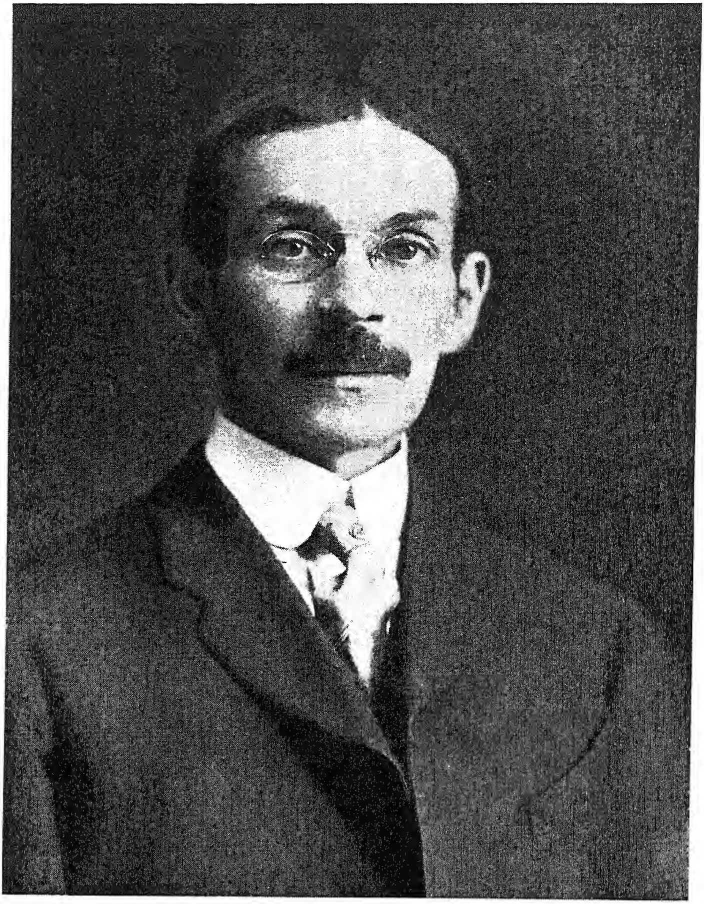
"Selected References on Elementary-School Instruction, Reading," *Elementary School Journal*, XXXV (October, 1934), 131–35.

With BERNICE E. LEARY. "What Makes a Book Readable?" *Journal of Adult Education*, VI (October, 1934), 408–11.

With OTHERS. *Special Methods and Psychology of the Elementary School Subjects*, pp. 54–69, 111–14. Review of Educational Research, Vol. V, No. 1. Washington: American Educational Research Association of the National Education Association, 1935.

"Summary of Reading Investigations" (July 1, 1933—June 30, 1934), *Journal of Educational Research*, XXVIII (February, 1935), 401–24.

PLATE VIII



EDMUND BURKE HUEY, PH.D.

Born December 1, 1870; died December 30, 1913; A.B., Lafayette, 1895; Ph.D., Clark, 1899; research in reading and eye-movements, Clark University, Johns Hopkins University.

"Problems of Reading Disabilities Requiring Scientific Study," *Elementary English Review*, XII (April, 1935), 96–100.

"The Place of Oral Reading in an Improved Program of Reading," *Elementary School Journal*, XXXVI (March, 1936), 517–26. Also in *The Application of Research Findings to Current Educational Practices*, pp. 91–98. Official report of the American Educational Research Association, 1935. Washington: American Educational Research Association of the National Education Association.

With Bernice E. Leary. *What Makes a Book Readable?* Chicago: University of Chicago Press, 1935. Pp. xviii+358.

"Summary of Reading Investigations" (July 1, 1934—June 30, 1935), *Journal of Educational Research*, XXIX (February, 1936), 407–32.

"The Nature and Extent of Reading Deficiencies among College Students." An address delivered at the Joint Meeting of the National Society of College Teachers of Education and the American Educational Research Association, February 25, 1936. Sixty-sixth Annual Convention of the Department of Superintendence of the National Education Association, St. Louis, Missouri, February 22–27, 1936.

Dr. Edmund B. Huey

"Preliminary Experiments in the Physiology and Psychology of Reading," *American Journal of Psychology*, IX (July, 1898), 575–86.

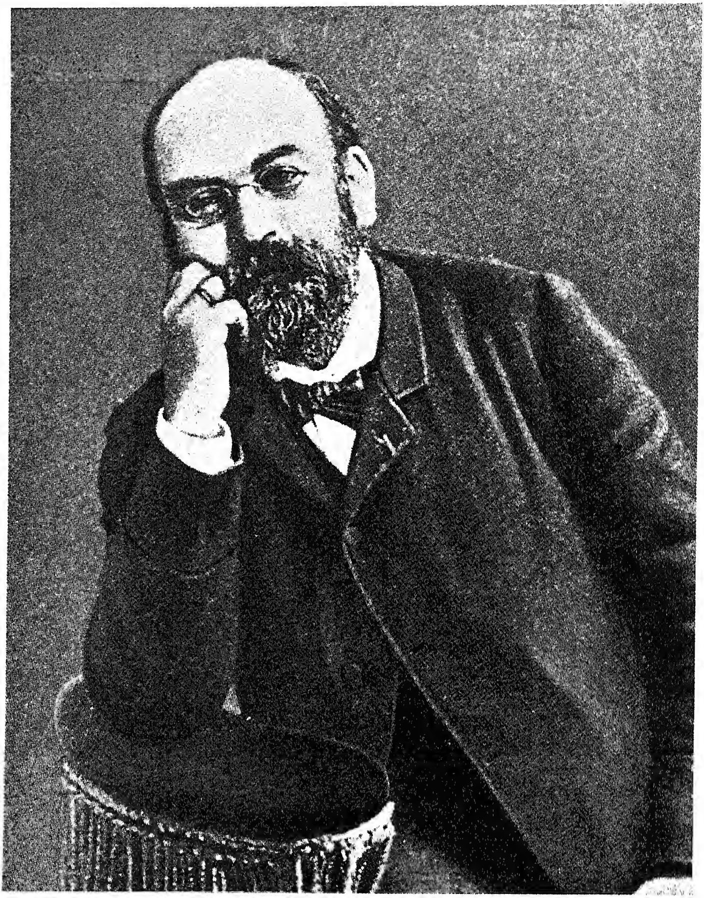
"On the Psychology and Physiology of Reading," *ibid.*, XI (April, 1900), 283–302.

"On the Psychology and Physiology of Reading," *ibid.*, XII (July, 1901), 292–312.

The Psychology and Pedagogy of Reading. (Also published with the title *The History and Pedagogy of Reading*.) New York: Macmillan Co., 1908. Pp. xvi+469.

Dr. Louis Emile Javal was born in Paris, France, May 5, 1839. He studied at the School of Mines, and was an engineer before he became

PLATE IX



Louis Emile Javal, M.D.

Born May 5, 1839; died January 19, 1907; research in eye-movements carried on in Paris, France. Biography and list of publications in *Annales d'oculistique*. CXXXVII (1907), 13–193, picture facing p. 13.

interested in ophthalmology. Javal's interest in visual anomalies was aroused by a case of strabismus in a near relative. He studied medicine and received the medical degree at Paris in 1869.

Javal's greatest service to ophthalmology was in the field of physiologic optics. Among his more important works are: the first French translation of Helmholtz' *Physiologic Optics*, the famous *Manuel du strabisme*—probably his most important work—*Memoires d'ophthalmométrie*, and later, after he had lost his sight, *Entre aveugles*.[2] An interesting biography and a complete list of his extensive publications appear in *Annales d'oculistique*.[3]

While carrying on his research Javal became vitally interested in the study of problems related to reading. His work as a pioneer in reading research has had a profound influence on later research. Even today we find the name of Javal frequently mentioned in current literature in this field. Studies in connection with reading problems are reported in the following publications:

"Hygiène de la lecture," *Bulletin de la Société de Médecine* (1878), p. 569, et *Comptes rendus de la Société de Biologie* (1878), p. 363.

"Conditions de la lecture facile," *Comptes rendus de la Société de Biologie* (1879), p. 8.

[2] *On Becoming Blind*, trans. into English by Carroll Edson.

[3] CXXXVII (1907), 13–193.

"Les livres et le myopie," *Revue scientifique* (22 novembre, 1879), p. 493, et *Revue d'hygiène* (1880), p. 337.

"L'évolution de la typographie considérée dans ses rapports avec l'hygiène de la vue," *Revue scientifique* (25 juin, 1881), p. 802, et *Revue d'hygiène* (1881), p. 611.

"Essai sur la physiologie de la lecture," *Annales d'oculistique:*

Introduction (mars–avril, 1878), pp. 97–99

Chap. i, "Caractères épigraphiques" (mars–avril, 1878), pp. 99–107

Chap. ii, "Caractères manuscrits" (mars–avril, 1878), pp. 107–17

Chap. iii, "Caractères typographiques" (mai–juin, 1878), pp. 240–74

Deuxième partie—"Influence de l'éclairage" (septembre–octobre, 1878), pp. 155–57

Chap. iv, "De l'acuité visuelle indépendamment de l'éclairage" (novembre–decembre, 1878), pp. 157–67

Chap. v, "Influence d'éclairage sur l'acuité visuelle" (janvier–février, 1879), pp. 61–73

Chap. vi, "Conclusion à tirer de ce qui précède" (mars–avril, 1879), pp. 157–62

Chap. vii, "La lecture dans ses rapportes avec les ametropies II (juillet–août, 1879), pp. 72–81

Chap. viii, "La myope des écoliers et l'éclairage des écoles" (septembre–octobre, 1879), pp. 159–70

Quatrième et dernière partie (novembre–decembre, 1879), pp. 242–53.

Dr. Charles H. Judd

"Some Facts of Binocular Vision," *Psychological Review*, IV (July, 1897), 374–89.

"Binocular Factors in Monocular Vision," *Science*, VII (February 25, 1898), 269–71.

"Retinal Images and Binocular Vision," *ibid.*, VII (March 25, 1898), 425–26.

"Visual Perception of the Third Dimension," *Psychological Review*, V (July, 1898), 388–400.

"An Optical Illusion," *ibid.*, V (May, 1898), 286–94.

PLATE X

Charles Hubbard Judd, Ph.D.

Charles F. Grey Distinguished Service Professor of Education, and Head, Department of Education, University of Chicago, Chicago, Illinois. Born February 20, 1873; A.B., Wesleyan, 1894; Ph.D., Leipzig, 1896; research in reading and eye-movement photography, Wesleyan University, New York University, University of Cincinnati, Yale University, University of Chicago.

With C. N. McAllister and W. M. Steele. *General Introduction to a Series of Studies of Eye Movements by Means of Kinetoscopic Photographs.* Psychological Review Monograph Supplements, No. 29 (VII [March, 1905], 1–16).

The Müller-Lyer Illusion. Psychological Review Monograph Supplements, No. 29 (VII [March, 1905], 55–81).

With H. C. Courten. *The Zöllner Illusion.* Psychological Review Monograph Supplements, No. 29 (VII [March, 1905], 112–39).

With C. N. McAllister and W. M. Steele. *Analysis of Reaction Movements.* Psychological Review Monograph Supplements, No. 29 (VII [March, 1905], 141–84).

With Donald J. Cowling. *Studies in Perceptual Development.* Psychological Review Monograph Supplements, No. 34 (VIII [June, 1907], 349–69).

Photographic Records of Convergence and Divergence. Psychological Review Monograph Supplements, No. 34 (VIII [June, 1907], 370–423).

"Practical Application of Reading," *Proceedings of the Sixty-first Annual Session of the Wisconsin Teachers Association* (1913), pp. 181–83.

"Reading Tests," *Elementary School Journal*, XIV (April, 1914), 365–75.

"Reading," *The Public Schools of South Bend, Indiana* (a survey conducted by the Department of Education of the University of Chicago under the direction of Dr. J. F. Bobbitt, 1914), pp. 125–31. Published with the Biennial Report of the Superintendent of Schools, South Bend, Ind., 1912–14.

"Reading," *Standards and Tests for the Measurement of the Efficiency of Schools and School Systems.* Fifteenth Yearbook of the National Society for the Study of Education, Part I, pp. 111–19. Bloomington, Ill.: Public School Publishing Co., 1916.

"Demonstration of the Gray Reading Tests," *Fourth Annual Conference on Educational Measurements.* Bulletin of the Extension Division, Indiana University, III (April, 1917), 45–56.

"Reading Tests," *ibid.*, pp. 57–61.

"Measurement of Reading," *Fifth Annual Schoolmen's Week Proceedings* (April 11–13, 1918), pp. 142–50. Philadelphia: Press of the University of Pennsylvania, 1918.

With OTHERS. *Reading: Its Nature and Development.* Supplementary Educational Monographs, No. 10. Chicago: Department of Education, University of Chicago, 1918. Pp. 192.

"The Re-organization of Reading in the Elementary Schools," *Report and Proceedings of the Sixty-fourth Annual Meeting of the New Jersey State Teachers Association* (1919), pp. 28–37.

"Relation of Sc ool Expansion to Reading," *Elementary School Journal*, XXIII (December, 1922), 253–66.

With G. T. BUSWELL. *Silent Reading: A Study of the Various Types.* Supplementary Educational Monographs, No. 23. Chicago: University of Chicago, 1922. Pp. xiv+160.

Psychology of Reading. A radio address on the rôle of eye-movements in reading. Chicago: University of Chicago Press, 1922. Pp. 7.

Autobiography of DR. CHARLES HUBBARD JUDD. *A History of Psychology in Autobiography*, II, 207–35. International University Series in Psychology, edited by Carl Murchison. Worcester, Mass.: Clark University Press, 1932.

Biographical sketch to 1909, by Dr. F. N. Freeman, *Zeta News*, Vol. XII, Nos. 3 and 4 (April, 1927), with bibliography of books published and articles contributed to periodicals and reference works to March, 1927.

DR. WALTER R. MILES

The Effects of Alcohol on Psycho-physiological Functions. Carnegie Institution of Washington, Publication No. 266, pp. 59–62, 79–83. Washington: Carnegie Institution of Washington, 1918. Pp. 144.

FRANCIS G. BENEDICT, M.D., WALTER R. MILES, and OTHERS. *Human Vitality and Efficiency under Prolonged Restricted Diet.* Carnegie Institution of Washington, Publication No. 280, pp. 159–65, 184–86, 597–602, 616–22. Washington: Carnegie Institution of Washington, 1919. Pp. xi+701.

Alcohol and Human Efficiency. Carnegie Institution of Washington, Publication No. 333, pp. 13, 15, 83, 115, 149, 152, 163–65, 184–201. Washington: Carnegie Institution of Washington, 1924. Pp. 298.

PLATE XI

Walter Richard Miles, Ph.D.

Professor of Psychology, Yale University, and Attending Psychologist, New Haven Hospital and Dispensary, New Haven, Connecticut. Born March 29, 1885; B.S., Pacific College, 1906; A.B., Earlham, 1908; A.M., Iowa, 1910; Ph.D., Iowa, 1913; research in reading and eye-movement photography, Wesleyan University, Nutrition Laboratory (Carnegie Institution of Washington), Boston, Massachusetts, Stanford University, Yale University.

"Eyeball Reflex Movement Associated with Voluntary and Reflex Winking." Proceedings of the Third Annual Meeting of the American Physiological Society, 1924. *American Journal of Physiology*, LXXII (March, 1925), 239.

With EUGENE SHEN. "Photographic Recording of Eye Movements in the Reading of Chinese in Vertical and Horizontal Axes," *Journal of Experimental Psychology*, VIII (October, 1925), 344–62.

"When Reading Your Eyes Move in Jumps," *Scientific American*, CXXXV (November, 1926), 354–56.

"The Peep-Hole Method for Observing Eye-Movements in Reading," *Journal of General Psychology*, I (1928), 373–74.

"The 'Old Panorama' Photo-Kymograph," *Journal of the Optical Society of America and Review of Scientific Instruction*, XVI (April, 1928), 283–86.

"The Study of Normal Eye Movements," Bulletin of lectures at the *Annual Convention of California State Association of Optometrists*, June, 1928, pp. 44–46.

With H. M. BELL. "Eye Movement Records in the Investigation of Study Habits," *Journal of Experimental Psychology*, XII (October, 1929), 450–58.

"The Eyeball's Shifting Center of Rotation," *Psychological Bulletin*, XXVI (January, 1929), 12.

"Horizontal Eye Movements at the Onset of Sleep," *Psychological Review*, XXXVI (March, 1929), 122–41.

"Sleeping with the Eyes Open," *Scientific American*, CXL (June, 1929), 489–92.

With DAVID SEGEL. "Clinical Observations of Eye Movements in the Rating of Reading Ability," *Journal of Educational Psychology*, XX (October, 1929), 520–29.

With H. R. LASLETT. "Eye Movement and Visual Fixation during Profound Sleepiness," *Psychological Review*, XXXVIII (January, 1931), 1–13.

With RAYMOND DODGE. "A Floating Mirror Technique for Recording Eye Movements," *American Journal of Psychology*, XLIII (January, 1931), 124–26.

"Elevation of the Eyeballs on Winking," *Journal of Experimental Psychology*, XIV (August, 1931), 311–32.

DR. EDWARD L. THORNDIKE

"Reading as a Means of Nature Study," *Education*, XIX (February, 1899), 368–71.

"The Measurement of Ability in Reading—Preliminary Scales and Tests," *Teachers College Record*, XV (September, 1914), 207–77.

"Tests of Silent and Oral Reading," *Indiana University Bulletin*, XII (September, 1914), 37–51.

"An Improved Scale for Measuring Ability in Reading," *Teachers College Record*, XVI (November, 1915), 445–67; XVII (January, 1916), 40–67.

"The Measurement of Achievement in Reading; Word Knowledge," *ibid.*, XVII (November, 1916), 430–54.

"The Psychology of Thinking in the Case of Reading," *Psychological Review*, XXIV (May, 1917), 220–34.

"Reading as Reasoning: A Study of Mistakes in Paragraph Reading," *Journal of Educational Psychology*, VIII (June, 1917), 323–32.

"The Understanding of Sentences: A Study of Errors in Reading," *Elementary School Journal*, XVIII (October, 1917), 98–114.

Thorndike Reading Scale, Alpha 2: Silent Reading, Grades 3 to 12 (out of print).

Directions for Thorndike Reading Scale, Alpha 2 , 1919 (out of print).

Reading Scales: The Understanding of Sentences. Monograph and set of scales. (Out of print; revised as Form 10 of the Thorndike-McCall Reading Scale.)

Reading Scales: Visual Vocabulary. Monograph and set of scales, 1919 (out of print).

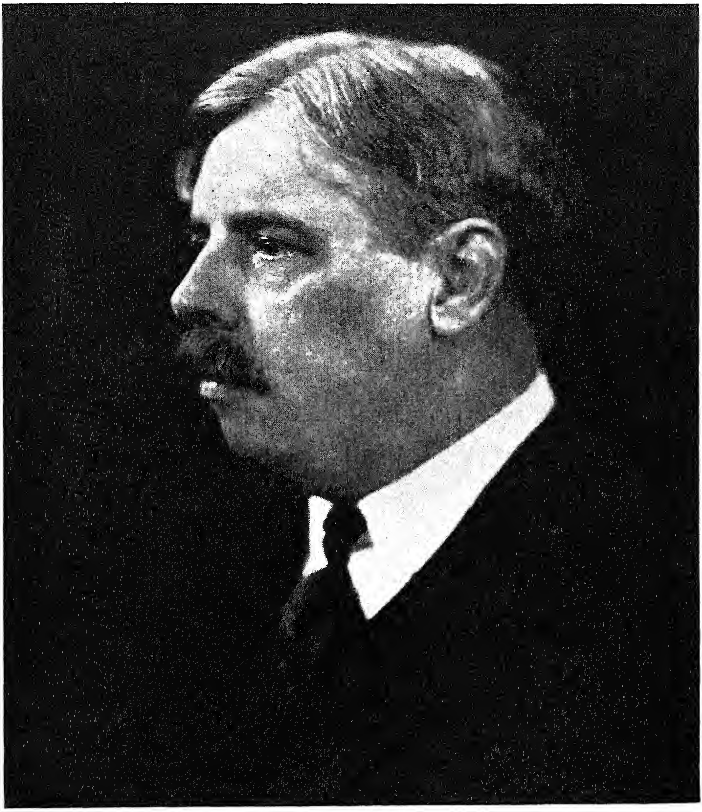
Thorndike Visual Vocabulary Scales: Directions for Their Use, 1920 (out of print).

"How Fast Can You Read? How Well Can You Read?" *Peoples Magazine*, V (December, 1920), 33–43, 47.

Thorndike-McCall Reading Scales for Grades 2 to 12. New York: Teachers College, Columbia University, 1921.

The Teachers Word Book of 10,000 Words. New York: Teachers College, Columbia University, 1921. Pp. vi+134.

PLATE XII



EDWARD LEE THORNDIKE, PH.D.

Professor of Education, and Director of the Division of Psychology, Institute of Educational Research, Teachers College, Columbia University, New York City. Born August 31, 1874; A.B., Wesleyan, 1895; A.B., Harvard, 1896; A.M., Harvard, 1897; Ph.D., Columbia, 1898; reading research, Columbia University.

"The Influence of First-Year Latin upon Ability to Read English," *School and Society*, XVII (February 10, 1923), 165–68.

"Improving the Ability to Read," *Teachers College Record*, XXXVI (October, November, December, 1934), 1–19, 123–44, 229–41.

The Teachers Word Book of 20,000 Words. New York: Teachers College, Columbia University, 1932 (rev.). Pp. vii+182.

"The Vocabularies of Juvenile Books," *Library Quarterly*, V (April, 1935), 151–63.

DR. MILES A. TINKER

"Reading Reactions for Mathematical Formulae," *Journal of Experimental Psychology*, IX (December, 1926), 444–67.

"Legibility and Eye Movement in Reading," *Psychological Bulletin*, XXIV (November, 1927), 621–38.

A Photographic Study of Eye Movements in Reading Formulae. Genetic Psychology Monographs, III, No. 2 (February, 1928), 68–182.

"Numerals versus Words for Efficiency in Reading," *Journal of Applied Psychology*, XII (March, 1928), 190–99.

With D. G. PATERSON. "Studies of Typographical Factors Influencing Speed of Reading, I," *ibid.*, XII (July, 1928), 359–68.

"Eye Movement Duration, Pause Duration, and Reading Time," *Psychological Review*, XXXV (September, 1928), 385–97.

"The Relative Legibility of the Letters, the Digits, and of Certain Mathematical Signs," *Journal of General Psychology*, I (1928), 472–96.

"How Formulae Are Read," *American Journal of Psychology*, XL (July, 1928), 476–83.

"Photographic Measures of Reading Ability," *Journal of Educational Psychology*, XX (March, 1929), 184–91.

With D. G. PATERSON. "Studies of Typographical Factors Influencing Speed of Reading, II and III," *Journal of Applied Psychology*, XIII (May and October, 1929), 205–19, 611–13.

"Visual Apprehension and Perception in Reading," *Psychological Bulletin*, XXVI (April, 1929), 223–40.

"The Influence of Letter Position on Range of Visual Apprehension," *ibid.*, XXVI (October, 1929), 611–13.

PLATE XIII

Miles Albert Tinker, Ph.D.

Associate Professor of Psychology, University of Minnesota, Minneapolis, Minnesota. Born August 22, 1893; A.B., Clark, 1921; A.M., Clark, 1922; Ph.D., Stanford, 1927; research in reading and eye-movement photography, Stanford University, University of Minnesota.

With D. ROBERTS and H. JACKSON. "Definite and Indefinite Preparation in the Visual Apprehension Experiment," *American Journal of Psychology*, XLII (January, 1930), 96–100.

With D. G. PATERSON. "Studies of Typographical Factors Influencing Speed of Reading IV," *Journal of Applied Psychology*, XIV (May, 1930), 211–17.

"The Relative Legibility of Modern and Old Style Numerals," *Journal of Experimental Psychology*, XIII (October, 1930), 453–61.

"An Apparatus for Recording Eye-Movements," *American Journal of Psychology*, XLIII (January, 1931), 115–18.

"Physiological Psychology of Reading," *Psychological Bulletin*, XXVIII (February, 1931), 81–98.

With D. G. PATERSON. "Studies of Typographical Factors Influencing Speed of Reading, V, VI, VII," *Journal of Applied Psychology*, XV (January, May, September, 1931), 72–78, 241–47, 471–79.

With F. D. GOODENOUGH. "Mirror-reading as a Method of Analysing Factors Involved in Word Perception," *Journal of Educational Psychology*, XXII (October, 1931), 493–502.

With F. D. GOODENOUGH. "The Retention of the Mirror-reading Habit after Two Years," *ibid.*, XXII (October, 1931), 503–4.

"Noiseless Exposure Apparatus," *American Journal of Psychology*, XLIII (October, 1931), 640–42.

The Effect of Color on Visual Apprehension and Perception. Genetic Psychology Monographs, XI, No. 2 (February, 1932), 61–136.

With D. G. PATERSON. "Studies of Typographical Factors Influencing Speed of Reading, VIII, IX, X," *Journal of Applied Psychology*, XVI (July, September, November, 1932), 388–97, 525–31, 605–13.

"The Influence of the Form of Type on the Perception of Words," *ibid.*, XVI (March, 1932), 167–74.

"The Relation of Speed to Comprehension in Reading," *School and Society*, XXXIII (July 30, 1932), 158–60.

"A Flexible Apparatus for Recording Reading Reactions," *Journal of Experimental Psychology*, XV (December, 1932), 777–78.

"Diagnostic and Remedial Reading," *Elementary School Journal*, XXXIII (December, 1932, and January, 1933), 293–306, 346–58.

"Use and Limitation of Eye-Movement Measures in Reading," *Psychological Review*, XL (July, 1933), 381–87.

"Experimental Study of Reading," *Psychological Bulletin*, XXXI (February, 1934), 98–110.

With A. FRANDSEN. "Evaluation of Photographic Measures of Reading," *Journal of Educational Psychology*, XXV (February, 1934), 96–100.

"The Rôle of Eye Movements in Diagnostic and Remedial Reading," *School and Society*, XXXIX (February 3, 1934), 147–48.

"Remedial Methods for Non-readers," *ibid.*, XL (October 20, 1934), 524–26.

"Illumination and the Hygiene of Reading," *Journal of Educational Psychology*, XXV (December, 1934), 669–80.

"Cautions Concerning Illumination Intensities Used for Reading," *American Journal of Optometry*, XII (1935), 43–51.

"Illuminating Intensities for Reading," *American Journal of Ophthalmology*, XVIII (November, 1935), 1036–38.

"Hygienic Lighting Intensities," *Journal of Industrial Hygiene*, XVII (November, 1935), 258–62.

With D. G. PATERSON. "Studies of Typographical Factors Influencing Speed of Reading, XI," *Journal of Applied Psychology*, XIX (December, 1935), 647–51.

With D. G. PATERSON. "Studies of Typographical Factors Influencing Speed of Reading, XII, XIII," *ibid.*, XX (February, 1926), 128–45.

Eye Movement, Perception, and Legibility in Reading," *Psychological Bulletin*, XXXIII (April, 1936), 275–90.

"Time Taken by Eye Movements in Reading," *Journal of Genetic Psychology*, XLVIII (1936), 468–71.

DR. GERALD A. YOAKAM

"The Effects of a Single Reading," *Report of the Society's Committee on Silent Reading*, pp. 90–102. Twentieth Yearbook of the National Society for the Study of Education, Part II. Bloomington, Ill.: Public School Publishing Co., 1921.

PLATE XIV

Gerald Alan Yoakam, Ph.D.

Professor of Education, Director of Research and of Courses in Elementary Education, University of Pittsburgh, Pittsburgh, Pennsylvania. Born November 18, 1887; A.B., Iowa, 1910; A.M., Iowa, 1919; Ph.D., Iowa, 1922; reading research, University of Iowa, University of Pittsburgh.

Nebraska Course of Study in Reading for Normal Training High Schools. Lincoln, Neb.: State Department of Public Instruction, 1922.

Silent Reading Exercises, edited by G. A. Yoakam. New Castle, Pa.: Board of Education, 1924.

"What Children Do When They Study," *School of Education Journal,* I (September–October and November–December, 1925), 12–16, 36–39.

With CHARLOTTE TRUBY. "The Effects of Certain Practice Exercises in Reading," *ibid.,* I (January–February, 1926), 60–61.

The Effects of a Single Reading. University of Iowa Studies in Education, Vol. II, No. 7. Iowa City, Iowa: University of Iowa, 1924. Pp. 100.

Reading and Study—More Effective Study through Better Reading Habits. New York: Macmillan Co., 1928. Pp. xi+502.

With OTHERS. *Looking Inside the School.* A series of eight radio talks. Pittsburgh, Pa.: University of Pittsburgh, 1928.

"Improvement of Instruction through Improvement of Reading," *School of Education Journal,* IV (September–October, 1928), 25–30.

Course of Study in Reading and Study, edited by G. A. Yoakam. Ellwood City, Pa.: Board of Education, 1930.

"How To Remember What One Reads," *Elementary English Review,* VII (April, 1930), 83–86.

"Major Abilities in Reading," *Montana Educator,* VI (April, 1930), 12.

"Reading and Study in Grade One," *ibid.,* VI (March, 1930), 11–12.

"What To Do with Non-readers in the Upper Grades," *Remedial Problems in the Teaching of Reading,* pp. 180–88. Eighteenth Annual Schoolmen's Week Proceedings, March 18–21, 1931. Philadelphia: Press of the University of Pennsylvania, 1931.

With R. G. SIMPSON. *An Introduction to Reading and Learning.* New York: Macmillan Co., 1934. Pp. x+498.

With R. G. SIMPSON. *Directed Study and Observation in Teaching.* New York: Macmillan Co., 1934. Pp. 234.

"Basic Elements Determining Ability To Read," *Educational Outlook,* IX (November, 1934), 1–11.

"What and How Well Do Adults Read," *The New Deal in Education*, pp. 463–72. Twenty-first Annual Schoolmen's Week Proceedings, March 14–17, 1934. Philadelphia: University of Pennsylvania Press, 1934.

Course of Study in Reading. Rankin, Pa.: Board of Education, 1935.

"The Supervision of Instruction in Reading," *Educational Method*, XV (October, 1935), 3–10.

"The Improvement of Reading and Study Habits," *Elementary School Journal*, XXXVI (November, 1935), 175–84.

With William C. Bagley and Philip A. Knowlton. *Reading To Learn—a Work-Type Informational Reader*. (Three-book series.) New York: Macmillan Co., 1935.

The Improvement of the Assignment. (Trans. into Polish.) New York: Macmillan Co., 1935. Pp. xii+398.

"The Improvement of Reading in the Middle Grades," *Education*, LVI (September, 1935), 1–6.

With Others. *Special Methods and Psychology of the Elementary-School Subjects*, pp. 54–69, 111–14. Review of Educational Research, Vol. V, No. I. Washington: American Educational Research Association of the National Education Association, 1935.

"Research Studies in Work-Type Reading: A Summary of Research Done at One University," *Journal of Educational Research*, XXIX (March, 1936), 532–43.

PART II

HISTORICAL SKETCH OF OBJECTIVE METHODS FOR THE STUDY OF EYE-MOVEMENTS ILLUSTRATED WITH PICTURES AND DIAGRAMS

CHAPTER II

OBJECTIVE METHODS FOR THE STUDY OF EYE-MOVEMENTS

Part II presents a historical sketch of the development of apparatus for the objective study of eye-movements, including diagrams and pictures of the eye-movement cameras built for this purpose. The data have been assembled from widespread sources, and in almost every instance the pertinent facts have been furnished by those who have actually designed the cameras and engaged in the experimental work.

Apparently Javal and Lamare were the first to observe and record[1] the fact that, during the act of reading, the eye moves across the page in a series of short fixations. This discovery has led to the development of elaborate techniques for the study of eye-movements. Excellent detailed descriptions and summaries[2] of these

[1] "D'après des recherches entreprises par M. Lamare dans notre laboratoire, l'œil subit même plusieurs saccades dans le courant de chaque ligne, environ une part 15 à 18 lettres de texte. Il est probable que, chez le myope, à chacune de ces saccades de l'œil répond une variation brusque de l'accommodation" (Louis Emil Javal, "Essai sur la physiologie de la lecture," *Annales d'oculistique*, LXXXII [novembre–decembre, 1879], p. 252 n.

[2] Charles H. Judd, C. H. McAllister, and W. M. Steele, *General Introduction to a Series of Studies of Eye-Movements by Means*

techniques have been published subsequently, but by way of review a brief résumé is made of the objective methods used in the study of eye-movements.

I. By direct observation
  a) A telescope or microscope is used to magnify the eye, and the observer counts the eye-movements of the reader

---

of Kinetoscopic Photographs. Psychological Review Monograph Supplements, No. 29 (VII [March, 1905], 1–16).

Edmund B. Huey, *The Psychology and Pedagogy of Reading*, pp. 15–50. New York: Macmillan Co., 1908.

William Anton Schmidt, *An Experimental Study in the Psychology of Reading*, pp. 4–15. Supplementary Educational Monographs, No. 2. Chicago: University of Chicago, 1917.

Clarence T. Gray, *Types of Reading Ability as Exhibited through Tests and Laboratory Experiments*, pp. 9, 83–90. Supplementary Educational Monographs, No. 5. Chicago: University of Chicago, 1917.

John A. O'Brien, *Silent Reading*, pp. 5–16. New York: Macmillan Co., 1921.

Clarence T. Gray, *Deficiencies in Reading Ability: Their Diagnosis and Remedies*, pp. 173–83. New York: D. C. Heath & Co., 1922.

Walter R. Miles, "The Peep-Hole Method for Observing Eye-Movements in Reading," *Journal of General Psychology*, I (1928), 373–74.

Miles A. Tinker, *A Photographic Study of Eye-Movements in Reading Formulae*. Genetic Psychology Monographs, III, No. 2 (February, 1928), 68–182.

M. D. Vernon, *The Experimental Study of Reading*, pp. 1–16. London, England: Cambridge University Press, 1931.

Sir William Stewart Duke-Elder, *Text Book of Ophthalmology*, Vol. I: *The Development, Form and Function of the Visual Apparatus*, pp. 567–631. St. Louis: C. V. Mosby Co., 1933.

b) A mirror is placed beside the printed material, and the observer counts the eye-movements by watching the image of the reader's face

c) A peephole about one-quarter of an inch in diameter is cut in the center of a printed page. The observer holds the peephole close to one of his own eyes—and counts the eye-movements as the subject reads from the other side of the page

II. By mechanical and electrical recording

a) A microphone attached to the upper eyelid records the sound made by the eye-movements. The investigator, by listening to these sounds, can count the eye-movements and determine the number of pauses

b) Various attachments to the cornea or pressure devices against the eyelid which, through a system of levers, record the eye-movements on smoked paper

c) Pneumatic capsules, supported in various ways so that they rest lightly against the upper eyelid. The movement of the eyeball compresses the capsule in such a way that a tambour attached to the capsule by a rubber tube moves and records any motion of the eye on a smoked paper revolving on a kymograph

III. By photographic methods

a) Kinetoscopic photographs.[3] Small pieces of Chinese white are placed on the cornea, generally on the nasal side, and the whole face is photographed with either direct or reflected sunlight as the source of illumination. The pictures thus secured are placed in a projection lantern and the eyes magnified a sufficient number of times to enable the in-

[3] Cf. picture of two subjects photographed by this method on p. 50.

PLATE XV

Fig. 1

Fig. 2

Courtesy Psychological Review Co.

Fig. 3

Fig. 4

The Eye-Movements of Two Subjects Being Photographed by the Kinetoscopic Method

Observe the small fleck of Chinese white on the nasal side of the cornea. The subject at the right is Dr. C. H. Judd. (Judd, McAllister, and Steele, "General Introduction to Series of Studies of Eye Movements by Means of Kinetoscopic Photographs," Pl. I, facing p. 16.)

vestigator to study the type and co-ordination of the eye-movements

b) Mirror-recording. A small mirror is held gently over the closed lid of one eye, and, as the eyes move in reading, the light reflected from the mirror is recorded on a photographic film

c) Corneal reflection method. As the eyes move in reading, a bright bead of light reflected from the cornea is recorded on a moving film. Dr. Raymond Dodge, who was the first to use this method, determined that the amplitude of the eye-movements in reading, as recorded on the film, is slightly less than one-half the actual displacement of the apex of the cornea, but always in the same direction.[4] The corneal reflection method has proved to be the most tangible technique for the study of eye-movements. It may be used with both children and adults, and is suitable for either individual or group studies

[4] *An Experimental Study of Visual Fixation.* Psychological Review Monograph Supplements, No. 35 (Vol. VIII, No. 4 [1907]).

CHAPTER III

CHRONOLOGICAL LIST OF APPARATUS DEVELOPED FOR EYE-MOVEMENT PHOTOGRAPHY

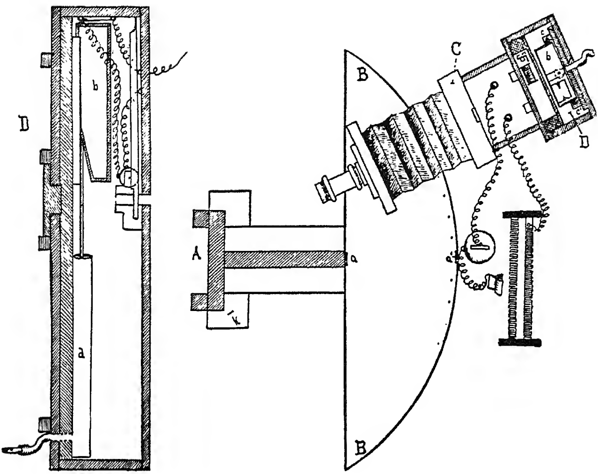
1899–1901.—The first camera ever used for recording eye-movements was designed by Dr. Raymond Dodge[1] at Wesleyan University, Middletown, Connecticut. The eye-movements and the time record (which was taken with either a spring pendulum or a Koenig tuning fork of one hundred vibrations per second) were recorded on a falling-plate, which was controlled in its fall by the escape of air from a cylinder. This apparatus was known as the "falling-plate" camera, and also as the "Dodge-Cline" camera.[2] The first experimental work in recording eye-movements was carried on with it at Wesleyan University.[3]

[1] All the cameras designed by Dr. Dodge and used by him in research were constructed by Mr. Francis H. J. Newton, now employed in the laboratories of the Institute of Human Relations, Yale University. At one time the Dodge falling-plate camera was manufactured and sold by Spindler & Hoyer, Göttingen, Germany, for M. 375.

[2] Cf. diagrams of the falling-plate camera, p. 53.

[3] Raymond Dodge and Thomas S. Cline, "The Angle Velocity of Eye-Movements," *Psychological Review*, VIII (March, 1901), 145–57; cf. Plate XVII, the first published photograph of eye-movements in reading, p. 54.

PLATE XVI

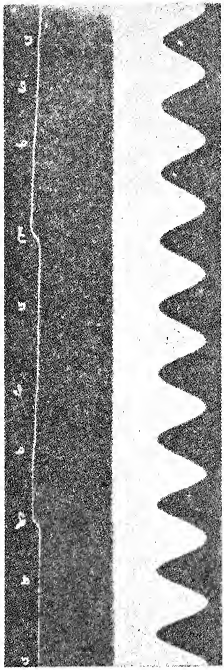


Courtesy Psychological Review Co.

DIAGRAMS OF THE "FALLING-PLATE" OR "DODGE-CLINE" CAMERA

The first camera for the photography of eye-movements by the corneal reflection method. (Raymond Dodge and T. C. Cline, *The Angle Velocity of Eye Movements*, p. 150.)

PLATE XVII



Courtesy Psychological Review Co.

THE FIRST PUBLISHED PHOTOGRAPH OF EYE-MOVEMENTS IN READING

The pendulum time record is shown at the left of the graph. (Dodge and Cline, *op. cit.*, Pl. I, facing p. 153.)

1903.—The first *binocular* eye-movement camera, constructed under the direction of Dr. Dodge at Wesleyan University some time before 1903 (now in a somewhat dismantled condition), is in the laboratories of the Institute of Human Relations at Yale University, New Haven, Connecticut. Binocular photographs are mentioned by Dr. Dodge in a report of his early research,[4] but apparently nothing has been published with reference to the binocular camera or the work carried on with it.

1903.—In reporting the experimental work at Wesleyan University[5] Dr. Dodge states that the only important improvement in his original apparatus is a more precise control of the falling-plate, brought about by the substitution of oil for air in the cylinder. Among the advantages of the apparatus he mentions that the camera operates under normal conditions of binocular vision and is capable of registering the movements of both eyes simultaneously.[6]

In reports of his experimental work during the years 1907 and 1908[7] Dr. Dodge refers to his ap-

[4] *Ibid.*, p. 156.

[5] "Five Types of Eye-Movement in the Horizontal Meridian Plane of the Field of Regard," *American Journal of Physiology*, VIII (January, 1903), 307–29.

[6] *Ibid.*, pp. 310–11.

[7] Raymond Dodge, *An Experimental Study of Visual Fixation*. Raymond Dodge and Allan R. Diefendorf, M.D., "An Experimental Study of the Ocular Reactions of the Insane from Photographic Records," *Brain*, XXXI (November, 1908), 451–89.

paratus as the "Wesleyan Apparatus" and the "Photochronograph."[8]

1903–4.—The plan of the Dodge camera was turned over to Dr. Walter F. Dearborn, and a camera,[9] built partly under the direction of Dr. Dodge at Wesleyan University, was used by Dr. Dearborn in research at Columbia University, New York City. The first systematic, and perhaps the classic, study of eye-movements in reading with the corneal reflection method was reported by Dr. Dearborn,[10] who made a careful analysis of the mechanical aspects of the reading process. The first subject to be photographed with the Columbia camera was Dr. E. L. Thorndike.[11] Just after the apparatus had been set up, Dr. Thorndike was invited to inspect it, and very obligingly acted as subject. Dr. Dearborn was much elated to find that the first photograph he secured was an excellent record. Dr. V. A. C. Henmon, now Professor of Psychology at the University of Wisconsin, also served as a subject in practically all this early experimental work at

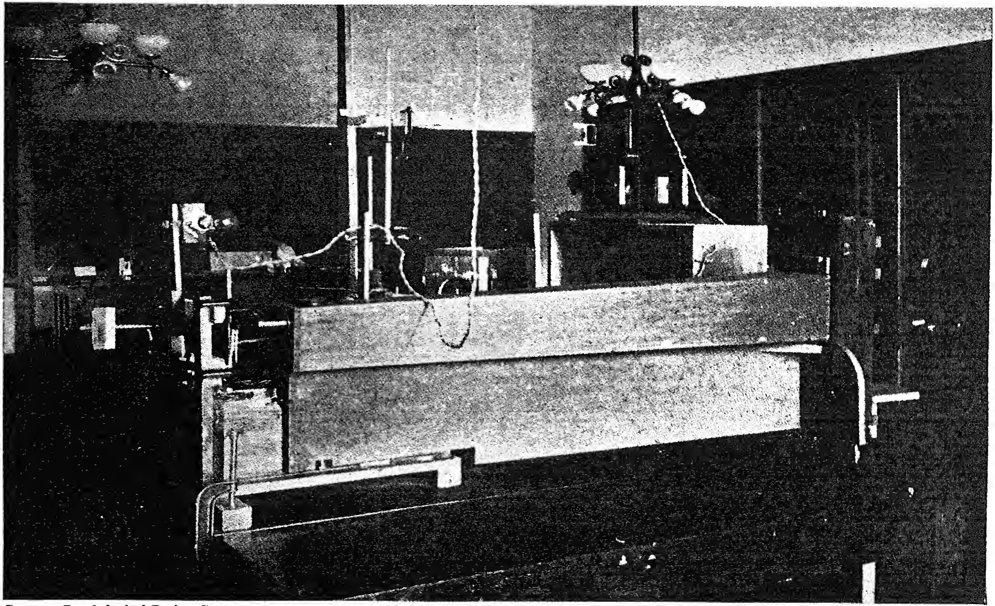
[8] Cf. picture of the entire apparatus, p. 57.

[9] Cf. picture of the apparatus used by Dr. Dearborn at Columbia University, p. 58.

[10] Walter F. Dearborn, *The Psychology of Reading.* Columbia University Contributions to Philosophy, Psychology and Education, Vol. XIV, No. 1. New York: Columbia University Press, 1906.

[11] The first photograph of eye-movements made by Dr. Dearborn at Columbia University is shown on p. 59.

PLATE XVIII

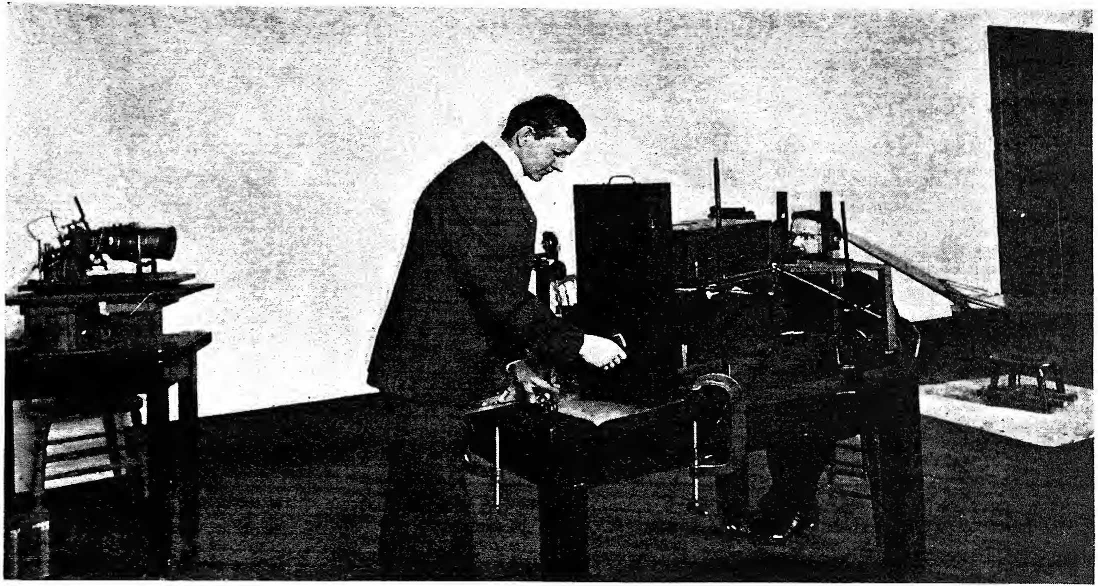


Courtesy Psychological Review Co.

THE "WESLEYAN APPARATUS" OR "PHOTOCHRONOGRAPH"

The entire apparatus is in position. (Dodge, *An Experimental Study of Visual Fixation*, Pl. III, facing p. 93.)

PLATE XIX

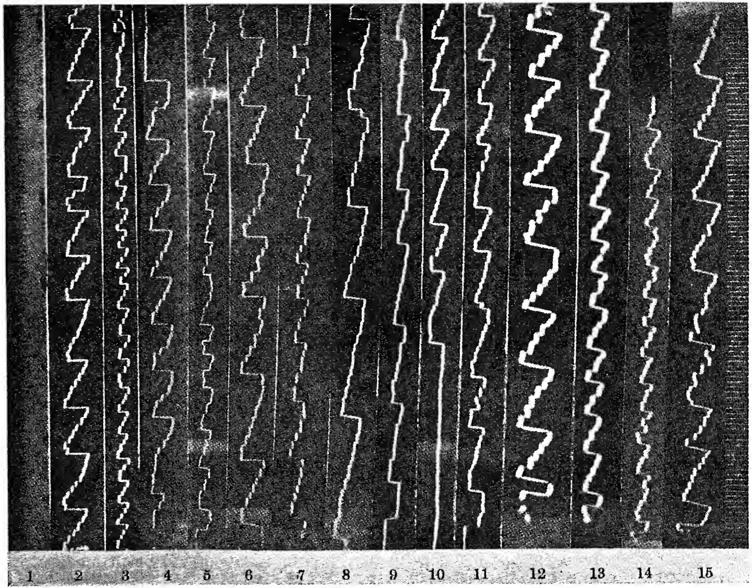


Courtesy Dr. Walter F. Dearborn

THE APPARATUS USED AT COLUMBIA UNIVERSITY BY DR. WALTER F. DEARBORN

Dr. Fred Lyman Wells, now psychologist at the Psychopathic Hospital, Boston, Massachusetts, is operating the camera, and Mr. G. C. Fracker, then a graduate student in the Department of Psychology, Columbia University, is serving as subject.

PLATE XX



Photographs of Eye-Movements Taken by Dr. Walter F. Dearborn at Columbia University.

Columns 2 and 3 are the reading-graphs of Dr. E. L. Thorndike. (Walter F. Dearborn, *The Psychology of Reading*, Pl. II, facing p. 17.)

Columbia University. An interesting arrangement was that Dr. Dearborn adjusted his apparatus so that it could be operated by the subject, who was thus able to photograph his own eye-movements while reading.

1905–7.—After experimenting with two types of cameras at the University of Wisconsin, Madison, Wisconsin, Dr. Dearborn evolved a satisfactory apparatus which he used there for a number of years.[12] This improved camera used a three-inch film about three feet long, which was propelled through a sort of press, operated much after the fashion of a clothes wringer.

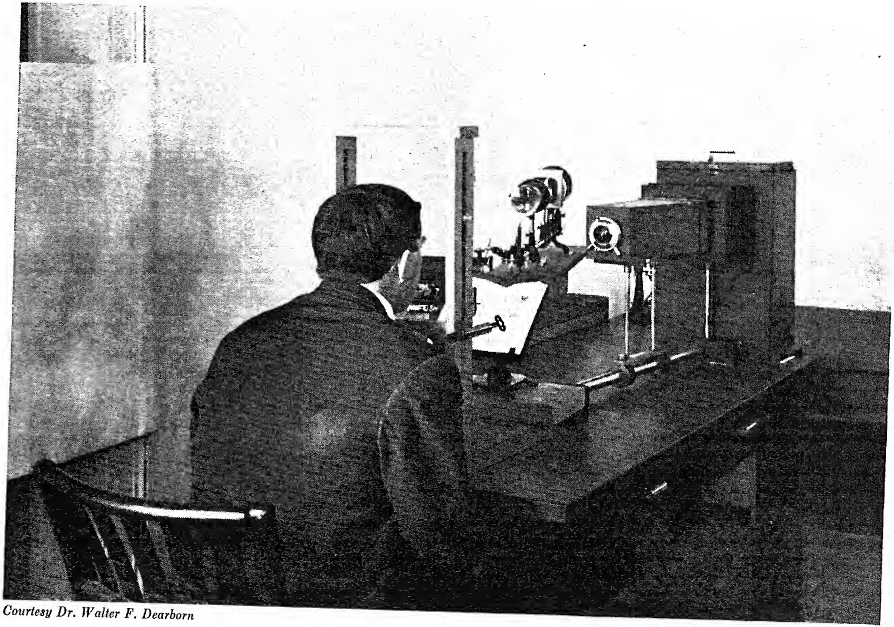
1910–11.—Dr. Clarence T. Gray, of the University of Texas, while working under Dr. Dearborn at the University of Chicago, Chicago, Illinois, built a camera in which both horizontally and vertically moving film was used. Later William Anton Schmidt[13] used this apparatus while working under Dr. F. N. Freeman. In 1915–16, when he was again at the University of Chicago, Dr. Gray rebuilt the Chicago camera. Dr. Guy T. Buswell improved the apparatus from time to time as he continued its use in the laboratories of the Department of Education.[14] These

[12] Pictures of the apparatus used by Dr. Dearborn at the University of Wisconsin are shown on pp. 61–62.

[13] *An Experimental Study in the Psychology of Reading*, pp. 4–15.

[14] Cf. early picture of the Gray camera at the University of Chicago, after modification by Dr. Buswell, p. 63. It has been further modified since this picture was taken.

PLATE XXI



Courtesy Dr. Walter F. Dearborn

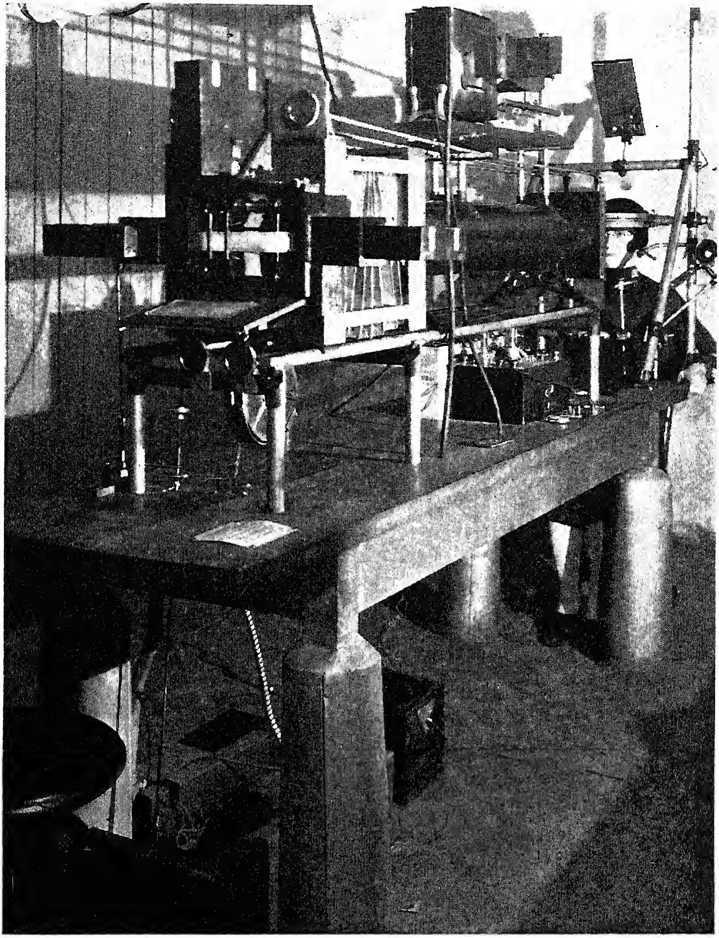
THE APPARATUS (FRONT VIEW) USED AT THE UNIVERSITY OF WISCONSIN BY DR. WALTER F. DEARBORN

Mr. Weber, a graduate student, is serving as subject

PLATE XXII

Courtesy Dr. Walter F. Dearborn

THE APPARATUS (REAR VIEW) USED AT THE UNIVERSITY OF WISCONSIN BY DR. WALTER F. DEARBORN
Mr. Weber, a graduate student, is serving as subject



Courtesy Dr. Guy T. Buswell

EYE-MOVEMENT CAMERA AT THE UNIVERSITY OF CHICAGO

Originally built by Dr. Clarence T. Gray, while working under Dr. Walter F. Dearborn, in 1910–11. Remodeled by Dr. Gray in 1915–16, and modified from time to time by Dr. Guy T. Buswell. The improved apparatus is still used in the laboratories of the Department of Education.

improvements included the introduction of motion-picture film (*ca.* 1921), which made possible the taking of very lengthy records.

1913.—Shortly after going to Harvard University, Cambridge, Massachusetts, Dr. Dearborn built a large camera, which was later reduced in size and modified by him in other ways. This apparatus was in use in the Harvard laboratories from 1913 until about 1929.

1912–13.—During the academic year 1913–14 Dr. Dodge acted as Experimental Psychologist at the Nutrition Laboratory, Boston, Massachusetts, where the Carnegie Institution of Washington was conducting an investigation into the physiological effects of ethyl alcohol on man.[15] The psychological laboratory of the Nutrition Laboratory was equipped for research along the lines developed by Dr. Dodge at Wesleyan University, and a camera for recording eye-movements was built by Mr. Newton under his direction. It had a horizontally moving-plate unit in addition to the falling-plate unit.[16]

Dr. Walter R. Miles, who carried on the psychological research at the Nutrition Labora-

[15] Raymond Dodge and F. G. Benedict, M.D., *Psychological Effects of Alcohol.* Carnegie Institution of Washington, Publication No. 232. Washington: Carnegie Institution of Washington, 1915.

[16] *Ibid.* The frontispiece, "A General View of the Psychological Laboratory of the Nutrition Laboratory," shows the Dodge camera in the foreground.

tory from 1914 to 1922, continued to use this camera. It was taken to Stanford University, Stanford University, California, by Dr. Miles in 1922 and was rebuilt[17] under his direction. He substituted a panoramic film[18] for the falling plate, introducing both horizontal and vertical movements, after Gray at Chicago. This was replaced later with motion-picture film as introduced by Buswell.[19]

The camera was used in research carried on by Shen,[20] Tinker,[21] Bell,[22] Laslett,[23] and others. After Dr. Miles left Stanford University, the apparatus was further modified to some extent under the direction of Dr. Albert Walton.[24]

[17] A picture of the Stanford apparatus used by Dr. Walter R. Miles is shown on p. 66.

[18] Cf. picture of the panoramic film unit, p. 68.

[19] Cf. description of the camera at the University of Chicago, pp. 60, 63.

[20] Walter R. Miles and Eugene Shen, "Photographic Recording of Eye-Movements in the Reading of Chinese in Vertical and Horizontal Axes," *Journal of Experimental Psychology*, VIII (October, 1925), 344–62.

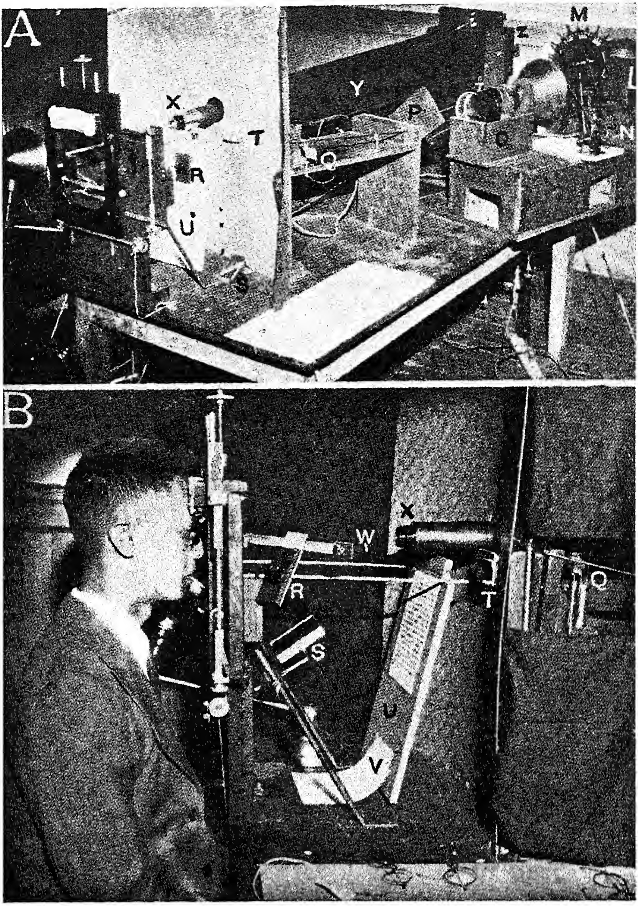
[21] Miles A. Tinker, *A Photographic Study of Eye-Movements in Reading Formulae.*

[22] Walter R. Miles and H. M. Bell, "Eye Movement Records in the Investigation of Study Habits," *Journal of Experimental Psychology*, XII (October, 1929), 450–58.

[23] Walter R. Miles and H. R. Laslett, "Eye Movement and Visual Fixation during Profound Sleepiness," *Psychological Review*, XXXVIII (January, 1931), 1–13.

[24] Cf. picture of the Stanford apparatus as it appeared in 1935, p. 67.

PLATE XXIV



Courtesy Psychological Review Co.

THE EYE-MOVEMENT CAMERA USED BY DR. WALTER R. MILES
AT STANFORD UNIVERSITY

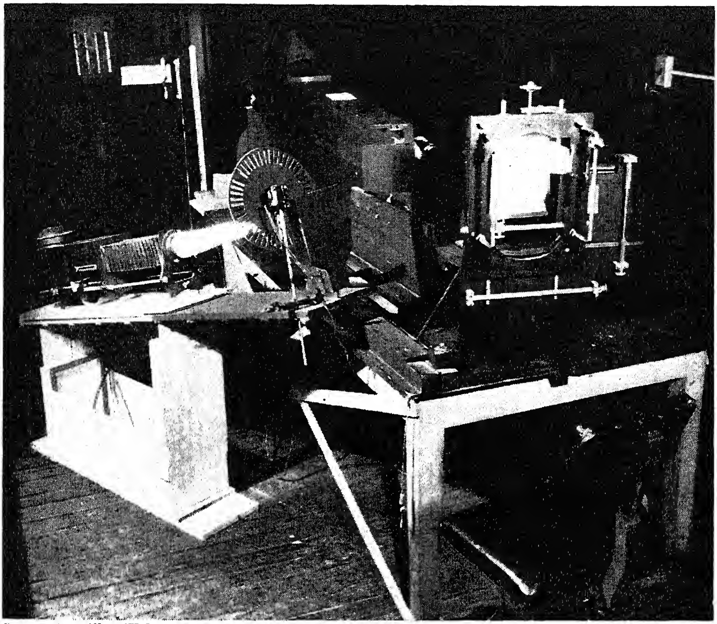
Miles and Shen, "Photographic Recording of Eye Movements in the Reading of Chinese in Vertical and Horizontal Axes," p. 346.

FIG. 1. Equipment for photographing eye-movements during reading:

(*A*) General view showing compact arrangement of the apparatus mounted as a unit on one table, which is securely braced to the floor.

(*B*) Subject in position for having eye-movements photographed during reading. The mirrors, *R* and *S*, for conducting the recording light to his eye, were at the subject's right and did not obstruct his binocular view of the copy.

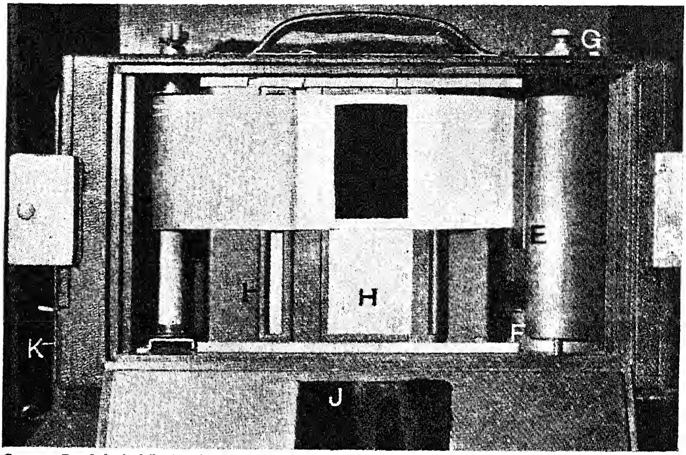
PLATE XXV



Courtesy Dr. Albert Walton

THE EYE-MOVEMENT CAMERA AT STANFORD UNIVERSITY AS IT APPEARED IN 1935

PLATE XXVI



Courtesy Psychological Review Co.

FILM BOX OF PANORAMIC TYPE WITH BACK OPENED AS WHEN FOCUSING FOR RECORDING EYE-MOVEMENTS

The film is given a continuous even movement by being rolled upon drum, *E*, which is revolved by spring motor, *F*, when the drum is clamped to the motor by nut, *G*. The focusing glass, *H*, may be moved behind the opening cut in the paper attached to the first end of the film. The box is easily clamped in any axes along which it is desired to move the film. (Miles and Shen, "Photographic Recording of Eye Movements in the Reading of Chinese in Vertical and Horizontal Axes," p. 349.)

1913–14.—Dr. Clarence T. Gray, at the University of Texas, Austin, Texas, built a camera similar to the Chicago apparatus. In a report of the experimental work carried on with it[25] Dr. Gray described the essential features of the apparatus. Dr. B. F. Holland modified the apparatus somewhat as he continued to use it in the laboratory at the University of Texas.[26]

1926.—At Cornell University, Ithaca, New York, Dr. J. P. Guilford constructed a camera of the Dodge type, the principal variation being the substitution of a panoramic film for the falling-plate, after the method of Miles and Shen.[27] His apparatus and technique, and the results of research carried on with the camera, have been described in some detail.[28]

1928.—A camera similar to the Cornell apparatus, with which a motion-picture film was used

[25] *Deficiencies in Reading Ability*, pp. 179–83.

[26] Cf. picture of the apparatus at the University of Texas, pp. 70–71.

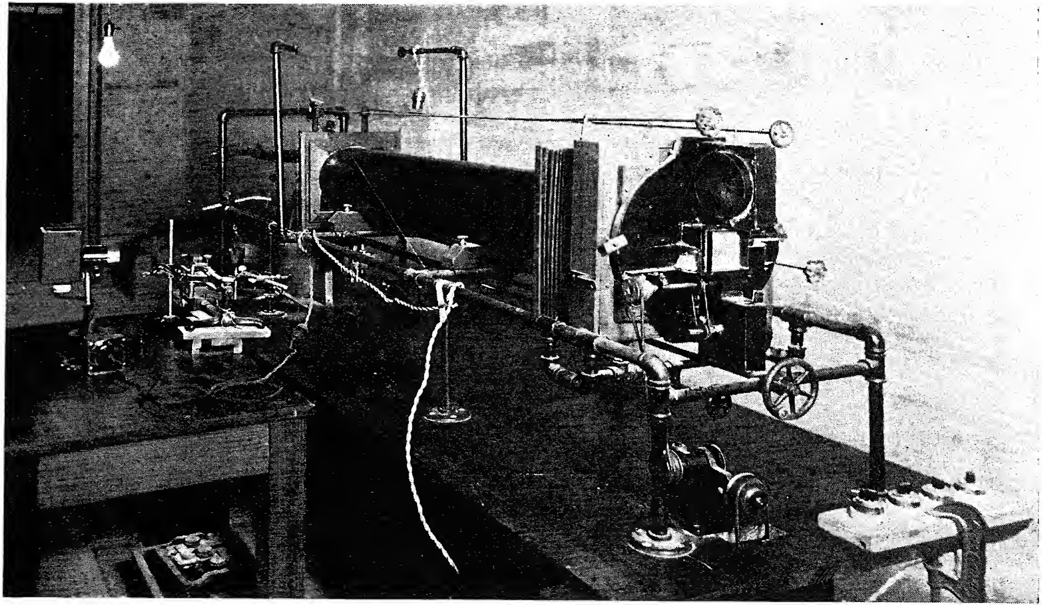
B. F. Holland, "Special Apparatus in the Laboratory of Educational Psychology, University of Texas," *American Journal of Psychology*, XLV (January, 1933), 139–41.

[27] Cf. description of camera at Stanford University, p. 65, and picture of panoramic film unit, p. 68.

[28] J. P. Guilford, " 'Fluctuations of Attention' with Weak Visual Stimuli," *American Journal of Psychology*, XXXVII (October, 1927), pp. 534–83.

J. P. Guilford and Karl M. Dallenbach, "A Study of Autokinetic Sensation," *American Journal of Psychology*, XL (January, 1928), 83–91.

PLATE XXVII

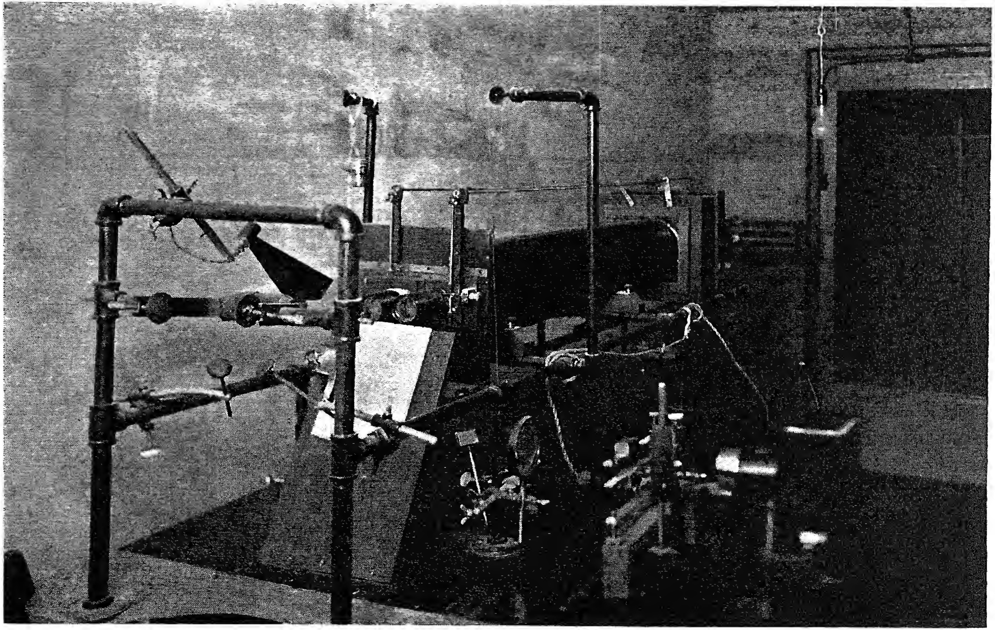


Courtesy Dr. B. F. Holland

LARGE EYE-MOVEMENT CAMERA (FRONT VIEW) AT THE UNIVERSITY OF TEXAS

Originally built by Dr. Clarence T. Gray and later modified by Dr. B. F. Holland

PLATE XXVIII



Courtesy Dr. B. F. Holland

LARGE EYE-MOVEMENT CAMERA (REAR VIEW) AT THE UNIVERSITY OF TEXAS

instead of the panoramic film, was built by Dr. Guilford at the University of Kansas, Lawrence, Kansas. The apparatus and the technique employed in his experimental work have been described by Dr. Guilford in various publications.[29]

1928.—A mirror-recorder for photographing eye-movements was constructed at Yale University by Dr. Roland C. Travis, under the direction of Dr. Dodge, who had used the mirror-recorder technique[30] as early as 1916. In the Dodge technique a frame[31] resembling a spectacle frame held small mirrors over the closed eyelids and, as the eyes moved, the reflected light from the mirrors was recorded on a photographic film. Eye-movements could be recorded while reading by placing a mirror over one eye only. At Western Reserve University, Cleveland, Ohio, Dr. Travis uses a monocular frame which permits

[29] *J. P. Guilford and Harry Helson*, "Eye Movements and the Phi-Phenomenon," *American Journal of Psychology*, XLI (October, 1929), 595–606.

J. P. Guilford, "Ocular Movements and the Perception of Time," *Journal of Experimental Psychology*, XII (August, 1929), 259–66.

[30] Raymond Dodge, "A Mirror-Recorder for Photographing the Compensatory Movements of Closed Eyes," *Journal of Experimental Psychology*, IV (June, 1921), 165–74.

Roland C. Travis, "Experimental Studies in Ocular Behavior, I: The Dodge Mirror-Recorder for Photographing Eye-Movements," *Journal of General Psychology*, VII (October, 1932), 311–27.

[31] Pictures of the frame and of a subject wearing it in position for binocular recording are shown on p. 73.

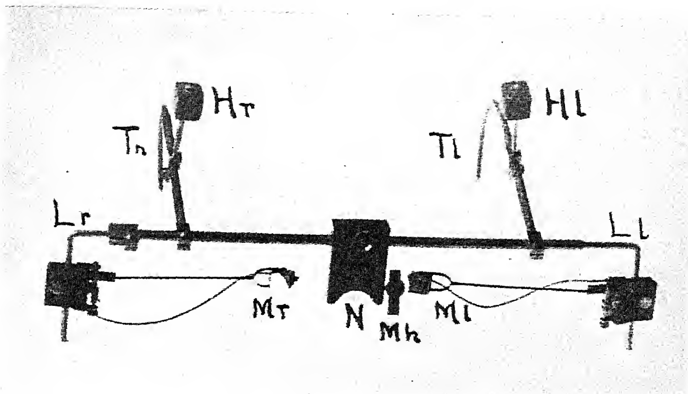
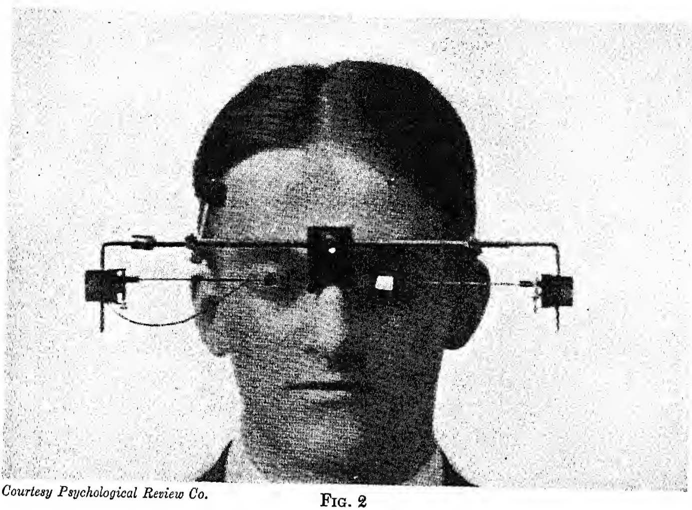


FIG. 1



Courtesy Psychological Review Co.

FIG. 2

DODGE MIRROR-RECORDER

FIG. 1.—Frame designed by Dr. Dodge. FIG. 2.—Frame in position for binocular recording. (Dodge, *A Mirror Recorder for Photographing the Compensatory Movements of Closed Eyes*, pp. 171 and 172.)

the subject to read with one eye while the movements of the other eye are recorded.[32] Experimental work with the mirror-recorder technique has been described in several publications.[33]

The mirror-recorder technique has recently been employed by Dr. Miles and Dr. Dodge with recumbent subjects. The apparatus consists of a concave mirror imbedded in paraffin, which fits over the cornea. In an article[34] describing the technique the authors state that it is the first technique for directly recording the position of fixation, and that the results are practically uninfluenced by head movements.

1928.—A camera of the Dodge type[35] was de-

[32] Cf. picture of the mirror-recorder apparatus used by Dr. Travis at Western Reserve University, p. 75.

[33] Roland C. Travis and Raymond Dodge, "Ocular Pursuit of Objects Which Temporarily Disappear," *Journal of Experimental Psychology,* XIII (February, 1930), 98–112.

Raymond Dodge, Roland C. Travis, and James C. Fox, Jr., M.D., "Optic Nystagmus, III: Characteristics of the Slow Phase," *Archives of Neurology and Psychiatry,* XXIV (July, 1930), 21–34.

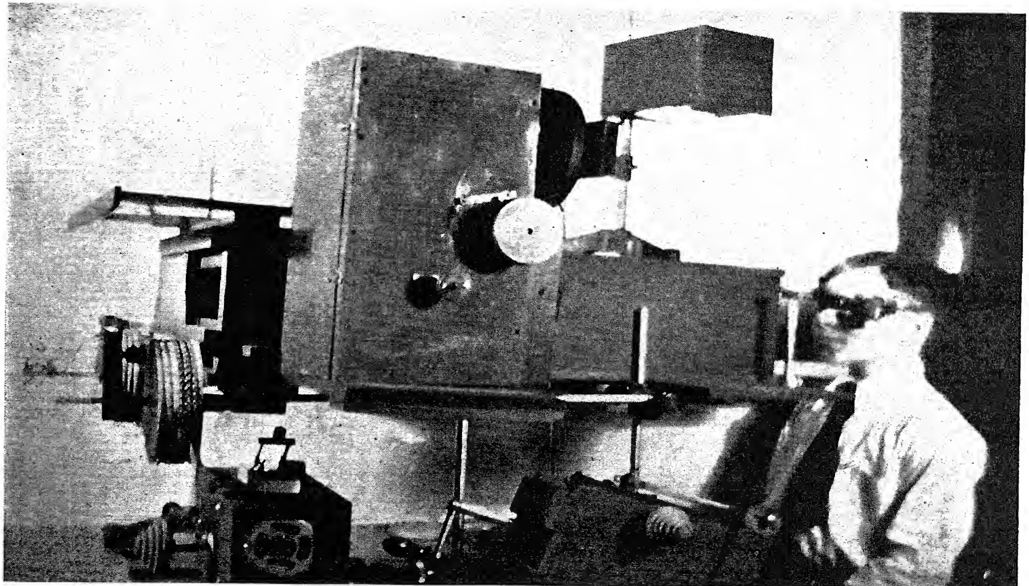
Roland C. Travis, "Relationship of Ocular Latency and Speed to Intellectual Performance," *Journal of Psychology,* I, First Half (1935–36), 129–37.

[34] Raymond Dodge and Walter R. Miles, "A Floating Mirror Technique for Recording Eye-Movements," *American Journal of Psychology,* XLIII (January, 1931), 124–26.

[35] Cf. diagrams of camera at the University of Cambridge, p. 76.

M. D. Vernon, "An Apparatus for Photographic Recording of Eye-Movements," *British Journal of Psychology (General Section),* XXI (July, 1930), 64–67.

PLATE XXX



Courtesy Dr. Roland C. Travis

MIRROR-RECORDER APPARATUS USED FOR THE PHOTOGRAPHY OF EYE-MOVEMENTS BY DR. TRAVIS AT WESTERN RESERVE UNIVERSITY, CLEVELAND, OHIO

The subject is reading with the right eye while the movements of the left eye are being recorded

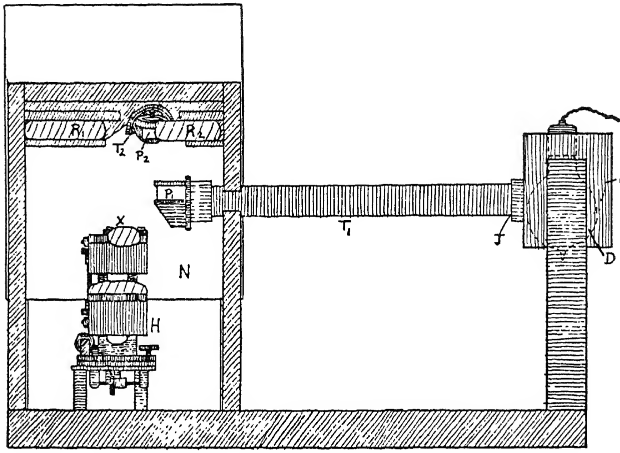
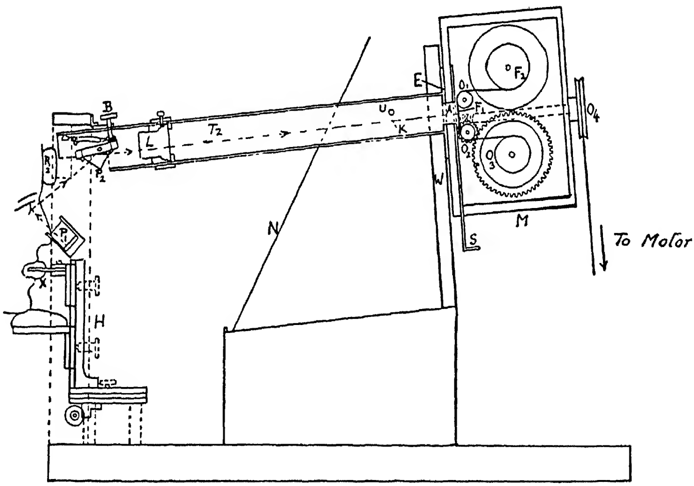


FIG. 1



Courtesy British Journal of Psychology

FIG. 2

DIAGRAMS OF EYE-MOVEMENT CAMERA (NOW DISMANTLED) USED BY MISS M. D. VERNON AT THE UNIVERSITY OF CAMBRIDGE, ENGLAND

FIG. 1.—Front view. FIG. 2.—Section along a vertical plane. (M. D. Vernon, "An Apparatus for the Photographic Recording of Eye-Movements," *British Journal of Psychology* [*General Section*], XXI [July, 1930], 65.)

signed by Miss M. D. Vernon, with the assistance of Professor Hartridge, in the psychological laboratory of the University of Cambridge, England, and constructed privately by Dr. E. A. Schuster at the National Institute for Medical Research, Hempstead, London. The apparatus and the technique used, and results of the experimental work, are fully described by Miss Vernon.[36]

1929.—At the University of Nebraska, Lincoln, Nebraska, Dr. Guilford was responsible for the construction of a camera[37] which was an improvement on those he had built at Cornell University and the University of Kansas. The camera is mentioned, but not described, in an article by Dr. Guilford.[38]

1929.—The Optokinetograph,[39] a camera which records the movements of both eyes, was built

[36] "The Movements of the Eyes in Reading," *British Journal of Ophthalmology,* XII (March, 1928), 130–39.

The Movements of the Eyes in Reading. Medical Research Council Committee on the Physiology of Vision, Vol. VIII (1930). Special Report Series No. 148. London, England: H. M. Stationery Office.

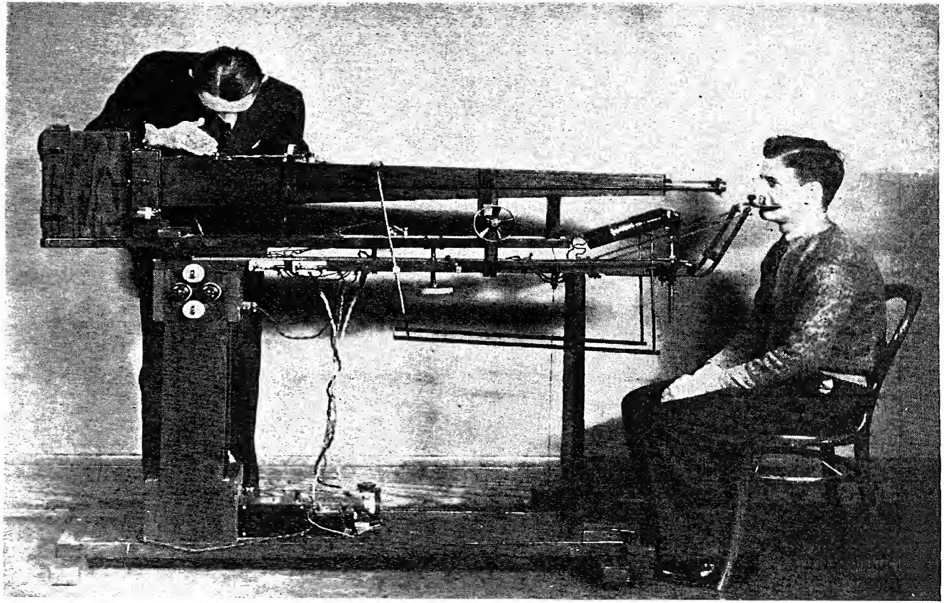
The Experimental Study of Reading.

[37] Cf. picture of the camera at the University of Nebraska, p. 78.

[38] J. P. Guilford and Roy B. Hackman, "Varieties and Levels of Clearness Correlated with Eye-Movements," *American Journal of Psychology,* XLVIII (July, 1936), 371–88.

[39] Cf. diagram of the Optokinetograph, p. 79; approximate cost, $2,500.

PLATE XXXII

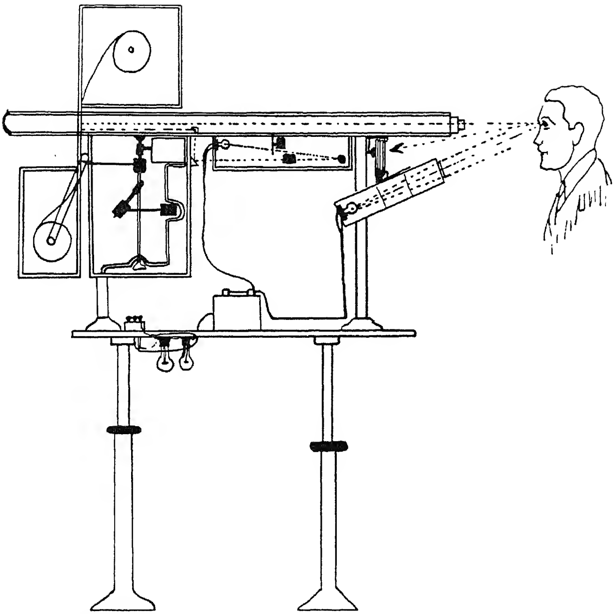


Courtesy Dr. William E. Walton

EYE-MOVEMENT CAMERA AT THE UNIVERSITY OF NEBRASKA

Built in 1929, under the direction of Dr. J. P. Guilford

PLATE XXXIII



Courtesy Forrest D. Comfort

DIAGRAM OF THE OPTOKINETOGRAPH AT HARVARD UNIVERSITY

for Harvard University by the Mann Instrument Company. The principles underlying its construction had been tested with a model built by Mr. Forrest D. Comfort at Harvard University in 1927, while working under the direction of Dr. Dearborn.

1930.—Dr. Harry Helson, who previously carried on research with Dr. Guilford at the University of Kansas, has designed a camera[40] which he is now using at Bryn Mawr College, Bryn Mawr, Pennsylvania. One study[41] has been reported, and other experimental work is being carried on under the direction of Dr. Helson.

1930–32.—At Oberlin College, Oberlin, Ohio, a camera[42] has been built under the direction of Dr. Homer E. Weaver, who formerly carried on research with the Dodge camera at Stanford University. Dr. Weaver has worked on a problem which involves the photography of eye-movements while reading music.[43] Two other studies have been completed and will be published.

1930.—At the University of Minnesota, Min-

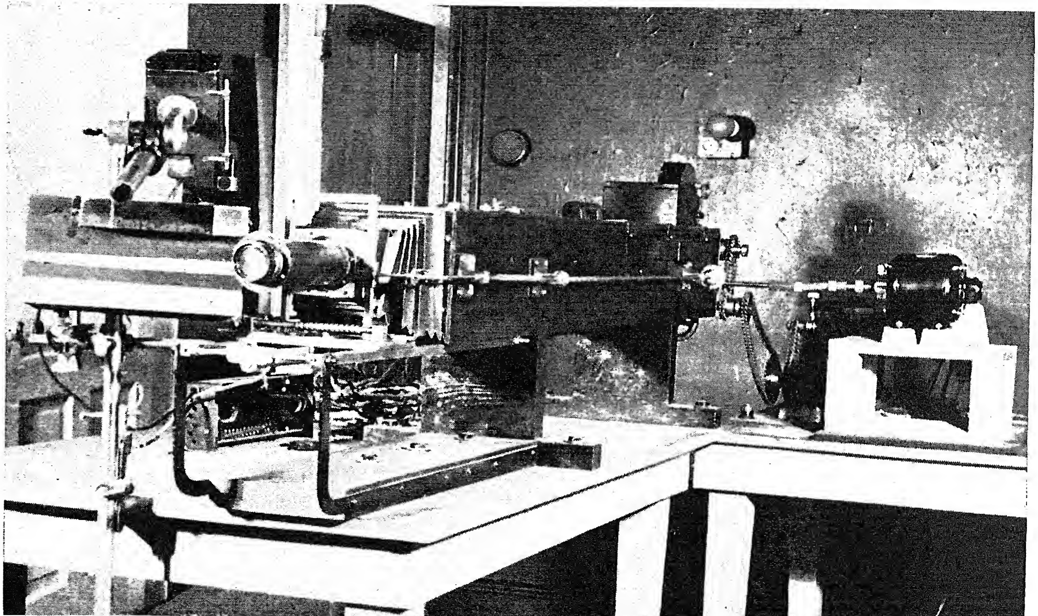
[40] Cf. picture of the camera at Bryn Mawr College, built by Mr. Norman Powell, p. 81.

[41] Olivia Futch, "A Study of Eye-Movements in the Reading of Latin," *Journal of General Psychology*, XIII (1935), 434–46.

[42] Pictures of the apparatus at Oberlin College are shown on pp. 82–83; approximate cost, $2,000.

[43] Homer E. Weaver, "Photographing Eye Movements during Music Reading," *Psychological Bulletin*, XXVIII (March, 1931), 211–12.

PLATE XXXIV



Courtesy Dr. Harry Helson

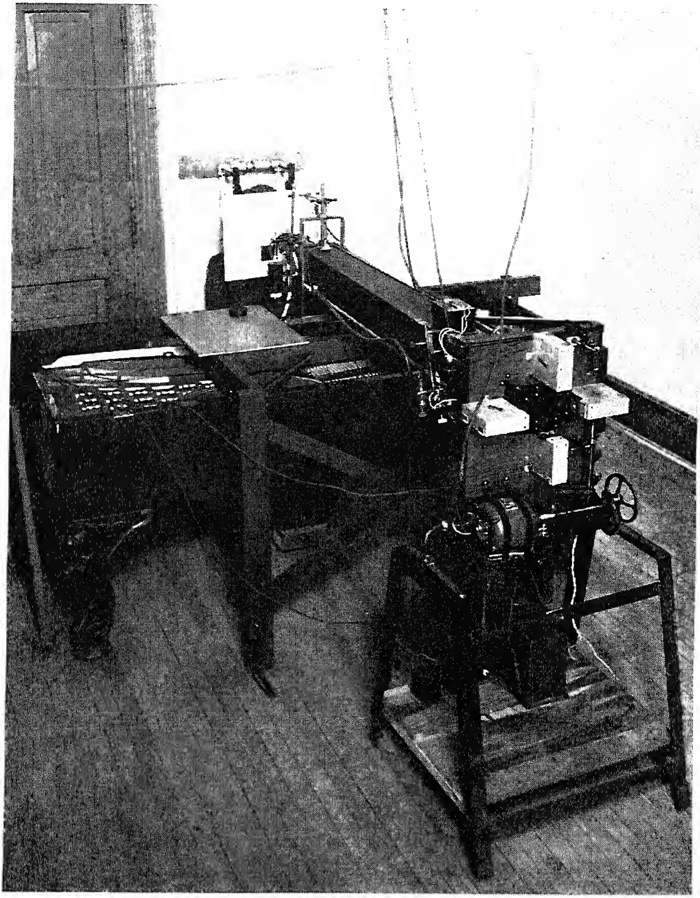
EYE-MOVEMENT CAMERA IN THE PSYCHOLOGICAL LABORATORY AT BRYN MAWR COLLEGE

PLATE XXXV

Courtesy Dr. Homer E. Weaver

EYE-MOVEMENT CAMERA (FRONT VIEW) AT OBERLIN COLLEGE
Subject Reading Music

PLATE XXXVI



Courtesy Dr. Homer E. Weaver

EYE-MOVEMENT CAMERA (REAR VIEW) AT OBERLIN COLLEGE

neapolis, Minnesota, Dr. Miles A. Tinker, who carried on research with the Dodge camera at Stanford University, supervised the building of a camera which he has described.[44] This is one of the most elaborate of the large cameras which have been constructed, and Dr. Tinker's extensive research has covered all phases of eye-movement photography.

1931.—At the University of Iowa, Iowa City, Iowa, Dr. Robert Y. Walker supervised the building of a camera[45] which recorded simultaneously binocular records of both horizontal and vertical movements. The apparatus, which has been dismantled, is described in reports of research at the University of Iowa.[46]

1932.—Two portable *monocular* eye-movement cameras were built by James Y. Taylor and

[44] Miles A. Tinker, *op. cit.*

"An Apparatus for Recording Eye Movements," *American Journal of Psychology*, XLIII (January, 1931), 115–18.

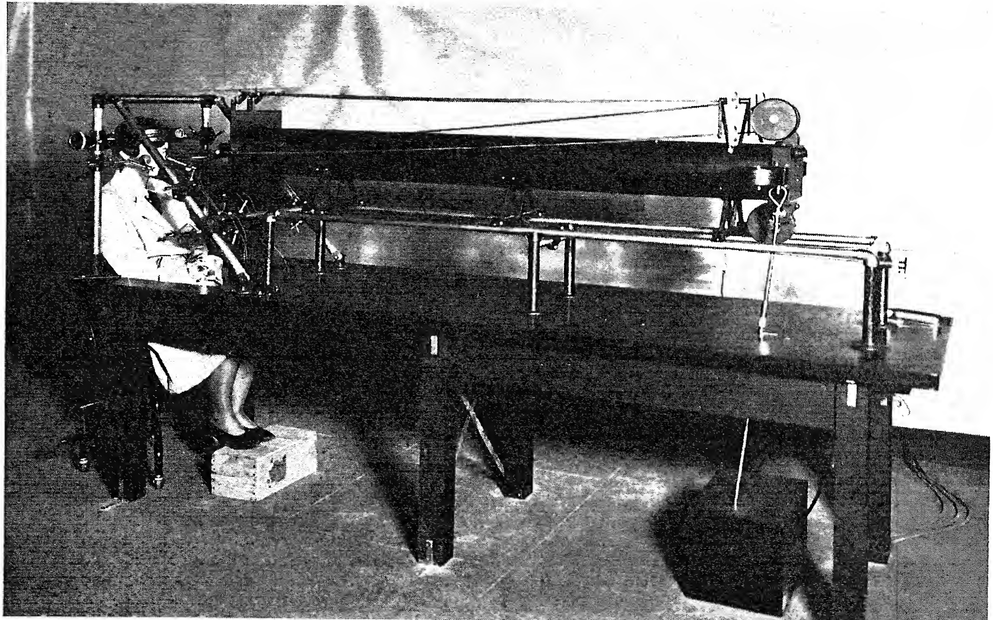
A picture of the apparatus at the University of Minnesota is shown on p. 85. It was built at an approximate cost of $3,000. The Departments of Psychology and Educational Psychology co-operated in the project, and Mr. R. O. Dauphin of the University Shops designed the new parts.

[45] Approximate cost, $150.

[46] Herbert H. Jasper and Robert Y. Walker, "The Iowa Eye-Movement Camera," *Science*, LXXIV (September 18, 1931), 291–93.

Robert Y. Walker, "Parallel Recording of Vertical and Horizontal Oscillations by Means of an Erecting Prism," *American Journal of Psychology*, XLVII (October, 1935), 696–97.

PLATE XXXVII



Courtesy Dr. Miles A. Tinker

LARGE EYE-MOVEMENT CAMERA IN THE PSYCHOLOGICAL LABORATORY AT THE UNIVERSITY OF MINNESOTA

Carl C. Taylor at Educational Laboratories, Inc., Brownwood, Texas. These cameras were similar in all essential points. The first camera[47] to be built was about fourteen inches high, and eleven by twenty-seven inches at the base. It weighed about twenty-four pounds, and operated on AC 110 volts, 60-cycle current. It was carried by a handle attached to the top of the camera box.

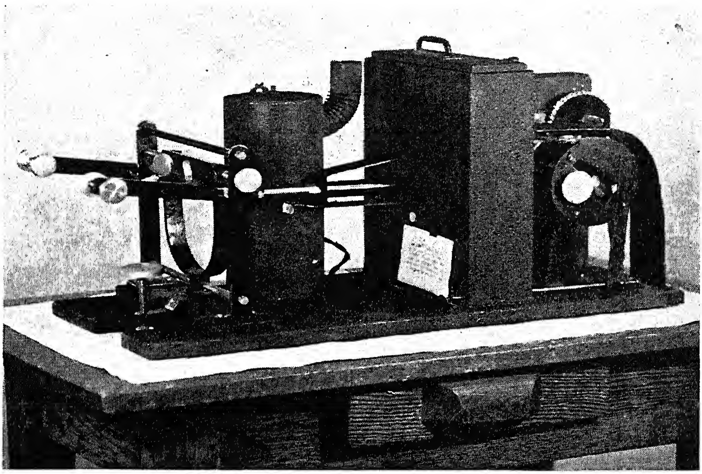
The portable monocular camera was designed for a 16-mm. film, but experience soon proved that this film was too narrow to be practicable as the corneal reflection sometimes ran off the edge of the film. A 35-mm. film was substituted, therefore, and proved to be very satisfactory. The roll of film was one hundred feet long, and the eye-movements of from fifty to seventy-five subjects could be photographed on a roll, according to the length of the reading selections used. The film box could be detached and carried to the dark room for developing, and it was not necessary to wait until the entire roll had been used, as any number of records could be cut off without exposing the unused portion of the film.

The film was moved by a synchronous motor[48] at the rate of half an inch per second. This methof of timing was superior to the old method of

[47] Cf. picture, p. 87.

[48] Taken from a portable electric phonograph. This motor was attached to the back of the box and the base of the camera.

PLATE XXXVIII



Courtesy Educational Laboratories, Inc.

THE FIRST *Portable Monocular* EYE-MOVEMENT CAMERA

Built by James Y. Taylor and Carl C. Taylor of Educational Laboratories, Inc., Brownwood, Texas.

counting dots made by breaking a beam of light[49] in that the total reading time could be quickly and accurately determined by measuring the total reading-graph with a steel tape. It was an advantage to have the motor in operation throughout the entire experimental period, as the subject could not tell when eye-movements were being recorded, and there was, therefore, less possibility of errors due to nervous strain.

The light for the corneal reflection was furnished by a 100-watt, non-frosted bulb, inclosed in a metal box. The bulb was so arranged that a section of the filament in it was visible through a hole in the metal box about an eighth of an inch in diameter. In the camera box was a metal wheel, connected with the motor that drove the film. The corneal reflection was directed through the rotating wheel, which was so perforated that the beam was broken thirty times per second. This feature made for greater accuracy in determining the duration of each fixation.

The reading material was presented on cards in a rack which was attached to the camera. A shutter concealed the card until the subject was in position for recording, but the top of the card

[49] In using the corneal reflection method, with many of the earlier types of cameras, the beam of light was broken before it reached the cornea by means of a tuning fork or similar device. The flicker which invariably accompanied the breaking of the beam was very disturbing to the subject as he read.

was exposed above the shutter, and two dots—one above the left margin and the other above the right margin of the reading material—were used as points of fixation before the actual reading began.

The subject seated himself at the camera, and was told to close his right eye and sight a target through a small hole underneath the lens tube. When he was able to see the bull's eye on the target, the corneal reflection was directed automatically to a mirror connected at an angle of 45° to a ground glass unit attached to the camera box and in front of the film.[50] The operator, who could see on the ground glass the corneal reflection coming from the mirror, brought the beam of light to a proper focus on the ground glass unit by means of a system of gears on the lens tube, controlled by a small dial. While the subject fixed his eyes on the two dots at the top of the camera card, the operator, who could follow the excursion of the corneal reflection in the ground glass unit, manipulated the headrest horizontally and the chin rest vertically by means of delicate screw adjustments, until the subject's head was in proper position for recording the corneal reflection on the film. When the correct focus was obtained, the operator turned aside the ground glass unit, which was hinged to

[50] The distance from the mirror to the ground glass was the same as the distance from the mirror to the film.

the camera box, and the corneal reflection fell directly on the film, ready for recording. The shutter was lowered, exposing the camera card, and photography began. This total process required only a few seconds, as a rule, and many subjects[51] could be photographed in a comparatively short time.

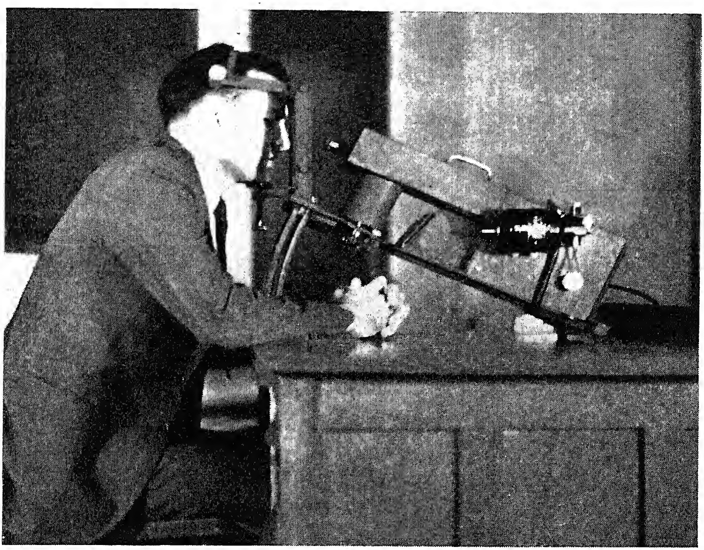
Photography could be carried on in a lighted room, and the fact that the camera permitted the photography of eye-movements while the subject wore lenses was also a decided advantage, as one accustomed to glasses does not always read normally without them in the experimental situation. The reading-graphs of those wearing bifocals or the lighter shades of tinted glasses were as distinct as those taken without lenses.

1932.—Carl C. Taylor and James Y. Taylor built the first portable *binocular* eye-movement camera[52] at Educational Laboratories, Inc., Brownwood, Texas. It was designed to permit the study of binocular imbalances and other irregularities which might affect reading efficiency. The principles underlying its construction and

[51] As each subject finished reading, his name was recorded on a numbered list, so that the reading-graphs were listed in the order in which they were taken and could be identified without difficulty after the film was developed.

[52] Cf. picture of the *portable binocular* eye-movement camera, p. 91.

PLATE XXXIX



THE FIRST *Portable Binocular* EYE-MOVEMENT CAMERA

Built by Carl C. Taylor and James Y. Taylor of Educational Laboratories, Inc., Brownwood, Texas, Henry McCallum serving as subject.

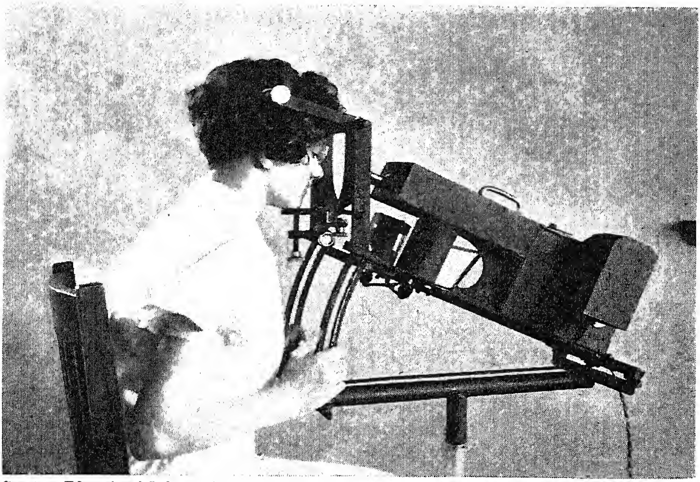
operation were essentially the same as those used in later models of the binocular camera.[53]

A 100-foot roll of 35-mm. film was inclosed in a metal box having two compartments (*H* and *I* in the diagram).[54] As the photography proceeded and the film (*L*) was exposed, it passed up and out of the first compartment (indicated by arrows) and down through the second compartment to a take-up box (*S*) and was automatically wound on a take-up roll (*M*). The film entered the take-up box through a slot in the top. The take-up roll held only about fifty feet of film. When the operator wished to develop the exposed portion of the film, he severed it by means of a cutting device which was attached to the top of the take-up box. As this device cut the film, it automatically closed the slot through which the film entered the take-up box. The take-up box was removed from the compartment, and an extra box, which was furnished with the camera, could be inserted without delay. The portion of the film which still extended into the

[53] The second model of the portable binocular camera built by Carl C. Taylor and James Y. Taylor (cf. picture, p. 93) had a separate metal stand, which could be adjusted and the camera raised so that subjects of all heights were in a comfortable position while their eye-movements were being photographed. Like the first model, it had a handle on the top of the camera box, by which the camera could be lifted or carried.

[54] Cf. p. 97.

PLATE XL

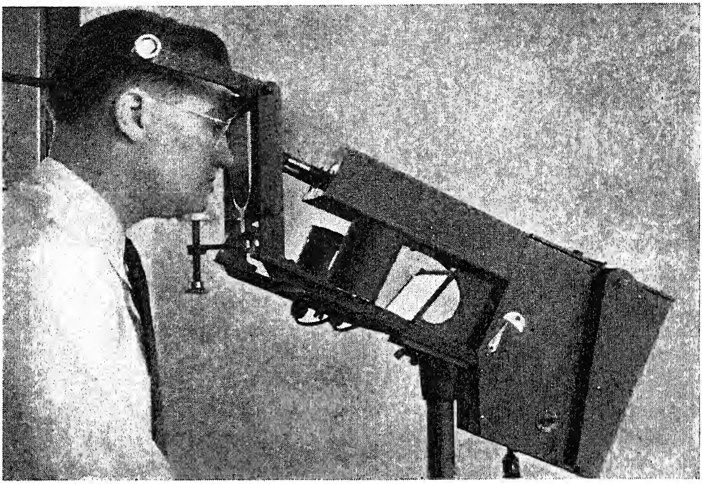


Courtesy Educational Laboratories, Inc.

SECOND MODEL OF THE PORTABLE BINOCULAR EYE-MOVEMENT CAMERA

Built by Carl C. Taylor and James Y. Taylor at Educational Laboratories, Inc., Brownwood, Texas. This was the first model with the new type of motor and the adjustable stand.

PLATE XLI



THE OCULO-PHOTOMETER, LATER KNOWN AS THE OPHTHALM-O-GRAPH

Earl A. Taylor is serving as subject. (Referred to in *The Improvement of Reading*, Arthur I. Gates, pp. 353 and 390.)

second compartment was pulled down, through the slot in the top of the extra take-up box, and threaded on the take-up spool, and the instrument was again ready for recording. The operator could remove any portion of the film[55] at any time without exposing or damaging the unused supply.

In the first portable binocular camera the film was moved by a small synchronous Bodine motor of 1/150 horse-power, geared down by a worm reduction to ten revolutions per minute final speed, which moved the film at the rate of half an inch per second.[56] The motor operated on AC 110 volts, 60-cycle current, and was attached to the side of the camera box.[57] This unit was too powerful to be satisfactory, and it was replaced by a Barber-Coleman synchronous motor—a very quiet motor with little vibration—with a spur gear reduction unit[58] which gave the shaft to the film sprocket a final speed of ten revolutions per minute. The film, therefore, moved at the same rate as in the first model. The new motor also was attached to the side of the camera,[59] but in later models the motor was housed in a container underneath the camera.[60]

[55] Fifty to seventy-five reading-graphs could be photographed on a roll, depending on the length of the reading selection.

[56] The reading-graphs were measured with a steel tape to determine the speed, as in the case of the monocular camera.

[57] Cf. picture, p. 91.

[58] Manufactured by Merkle-Korff Gear Co.

[59] Cf. picture, p. 93.

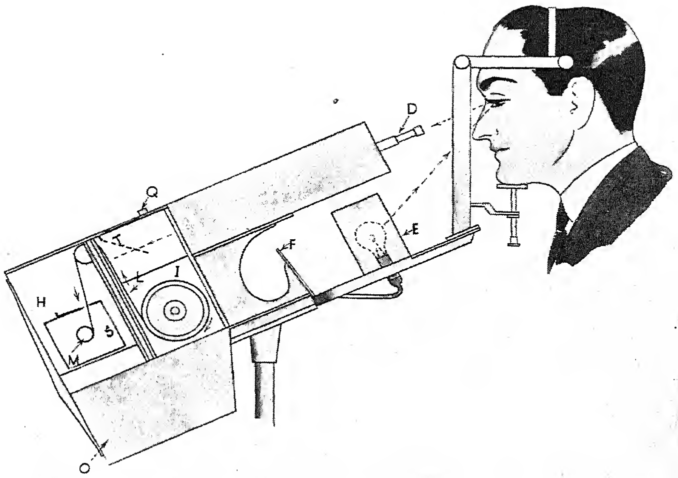
[60] Cf. "O" diagram, p. 97.

With the first binocular camera two 50-watt concentrated-filament G.E. Mazda projector lamps provided the illumination for the corneal reflection. The bulbs were inclosed in cylindrical boxes (*E*), and the filament in each bulb was so adjusted that part of it was exposed and could be seen by the subject through a small hole in the cylindrical box about an eighth of an inch in diameter. These lights were not practicable. The filaments were too fragile for use in a portable instrument that was frequently moved. Experiments were carried on to find a more serviceable type of light and at the same time to eliminate the glare which caused some discomfort when the subject was reading. It was found that the light supplied by two 21–candle-power automobile headlight bulbs,[61] placed at about ten inches from the eyes, was sufficient for recording and not intense enough to disturb the subject.

The fact that binocular irregularities could be studied more accurately, and that, as the light beam was not broken in recording, it was possible to get a continuous record of eye-movements, showing the irregularities at the beginning of each line as well as the movements from one fixation to another, made the binocular camera invaluable in many types of research which could

[61] A transformer used with these lights was housed with the motor in the container (*O*) underneath the camera; cf. diagram, p. 97.

PLATE XLII



Courtesy American Optical Co.

A Diagrammatic Illustration of the Photographic Principle of the Oculo-Photometer and the Ophthalm-O-Graph

not be carried on successfully without a continuous record of eye-movements.

The subject to be photographed was told to seat himself at the camera and adjust the chin rest so that, by sighting along the lower edge of the camera barrel, he could see the top of the card bearing the practice selection.[62] The operator, who stood at the back of the camera and opposite the subject, then adjusted the headrest, which was designed to eliminate any head movements which might interfere with the photography. He adjusted the telescoping lens tube units (*D*) so that the two corneal reflections were brought into position and focused on a mirror attached to the inside of the camera box, at the end of the camera barrel, at an angle of 45° (dotted line *T*), and directly in front of the moving film.[63] After the proper focus had been obtained, the operator pulled forward a small shutter (*Q*), which covered the ground glass, and the mirror was raised automatically so that the corneal reflection fell directly on the film. The subject was then in position for recording, the motor was started, and the shutter over the reading material was raised.

[62] Shown in the diagram as *F*. As in the case of the monocular camera, the reading material was covered with a shutter until the subject was in position for recording. The practice selection was fastened to the outside of the shutter, which was turned up to expose the selections used during the period of photography.

[63] The distance from the mirror to the film was the same as the distance from the mirror to the ground glass.

If the eye-movements were to be recorded while the subject read at infinity or observed objects at a distance, he was told to look along the upper instead of along the lower edge of the camera barrel.

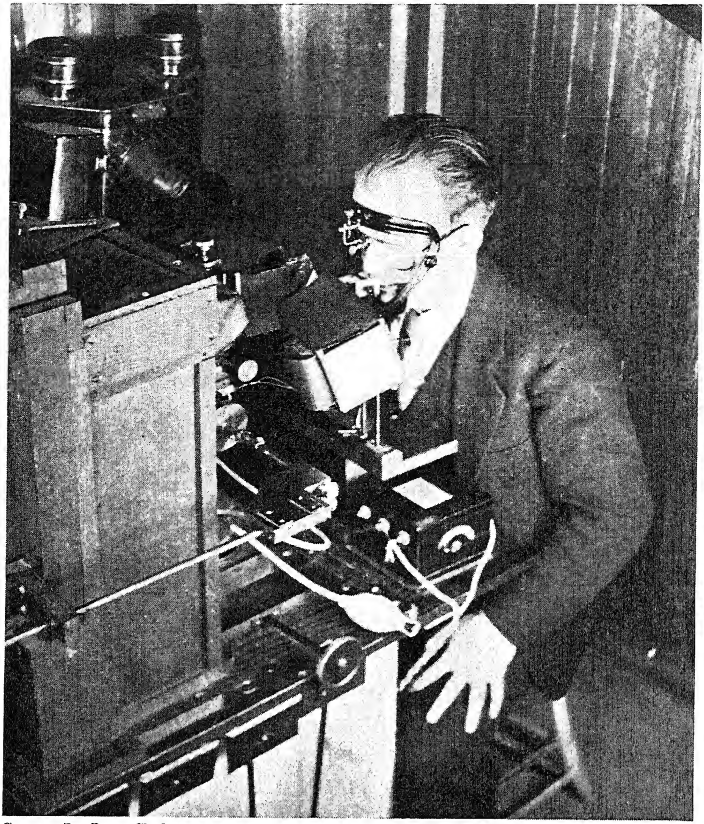
With the binocular camera the focusing process was greatly facilitated by the fact that the operator could move each entire lens tube unit instantly in any direction by grasping it between his thumb and forefinger. Further, owing to an arrangement of eccentric disks at the bases of the lens tubes, it was possible to adjust instantly to both narrow and wide pupillary distances. This camera was invaluable for survey work, not only because of the simplicity of operation, but also because a large number of subjects[64] could be photographed in a very short time. A further advantage was that the photography did not require a darkened room, and the eye-movements of subjects wearing lenses of all types could be photographed as distinctly as those of subjects without lenses.

1932–33.—Dr. Brant Clark built a camera[65] at the University of Southern California which photographed binocularly both horizontal and

[64] As in the case of the monocular camera, the reading-graphs were identified by means of a numbered list.

[65] Because of its size the entire apparatus at the University of Southern California could not be photographed conveniently, but a close-up view of the front showing a subject in position appears on p. 100; approximate cost, $500.

PLATE XLIII



Courtesy Dr. Brant Clark

EYE-MOVEMENT CAMERA AT THE UNIVERSITY OF SOUTHERN CALIFORNIA

Close-up view of the front end, showing a subject in position

vertical movements. It has been described in reports of his experimental work.[66]

1933.—At the University of Chicago Dr. Buswell supervised the construction of a large camera.[67] By means of a prism a beam of light is split, one part being photographed on a horizontally moving film and the other on a vertically moving film, thus recording the movements of the same eye on both films. The apparatus has been used in an excellent study of the psychology of perception in art, the results of which have been published.[68]

1933.—At Lehigh University, Bethlehem, Pennsylvania, Dr. Adelbert Ford began the construction of a binocular camera which had not been finished in 1935.

1935.—The portable binocular camera, known as the Ophthalm-O-Graph,[69] is now distributed

[66] Brant Clark, "A Camera for Simultaneously Recording the Horizontal and Vertical Movements of Both Eyes," *American Journal of Psychology*, XLVI (April, 1934), 325–26.

"The Effect of Binocular Imbalance on the Behavior of the Eyes during Reading," *Journal of Educational Psychology*, XXVI (October, 1935), 530–38.

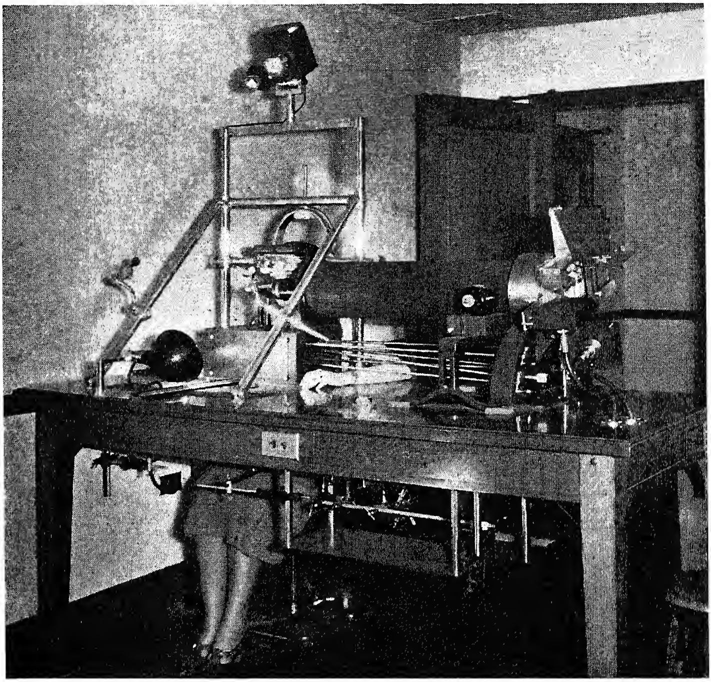
"Eye Movement Study of Stereoscopic Vision," *American Journal of Psychology*, XLVIII (January, 1936), 82–97.

[67] Cf. picture of a large camera built at the University of Chicago in 1933, by Mr. Ralph B. Larson, in the shops of the Department of Education, under the direction of Dr. Guy T. Buswell, p. 102; approximate cost, $4,000.

[68] Guy T. Buswell, *How People Look at Pictures* (Chicago: University of Chicago Press, 1935).

[69] Cf. picture, p. 103.

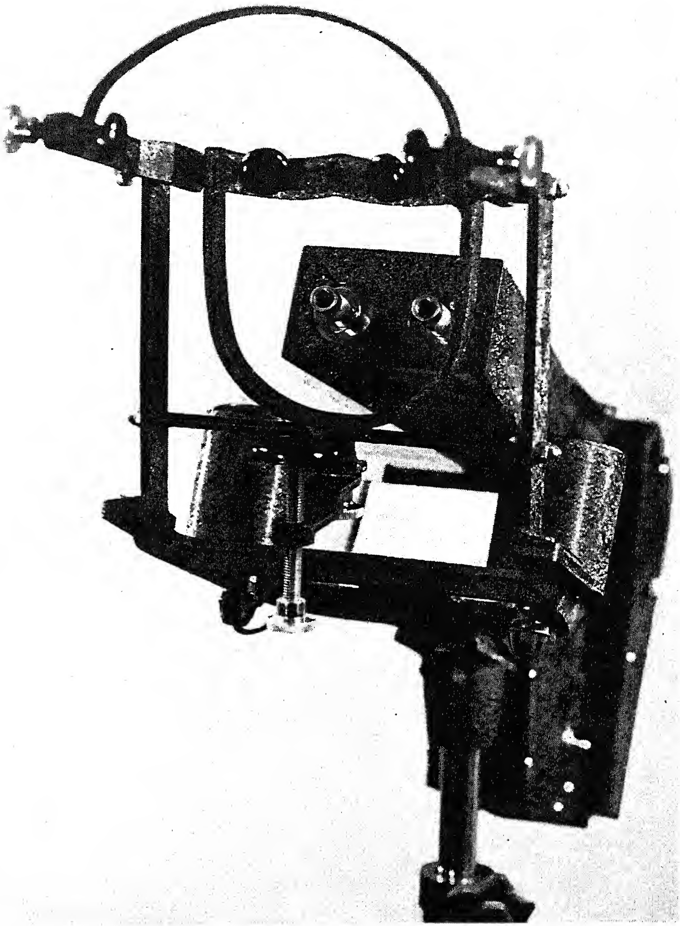
PLATE XLIV



Courtesy University of Chicago Press

A LARGE EYE-MOVEMENT CAMERA BUILT AT THE UNIVERSITY OF CHICAGO IN 1933

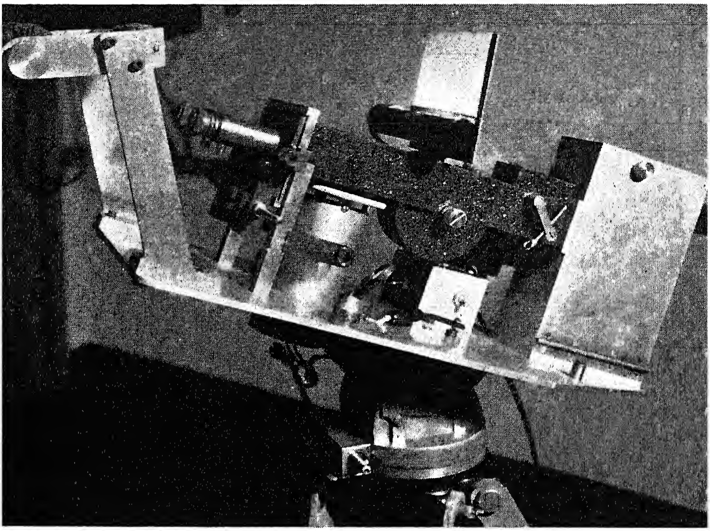
Taken from Buswell, *How People Look at Pictures*, Pl. VI, p. 13



Courtesy American Optical Co.

LATE MODEL OF THE OPHTHALM-O-GRAPH
(Weight, 37 lb.)

PLATE XLVI



rtesy Dr. Guy T. Buswell

A SMALL PORTABLE EYE-MOVEMENT CAMERA AT THE UNIVERSITY OF CHICAGO

(Completed in 1935)

by the American Optical Company, Southbridge, Massachusetts. The apparatus, as originally designed, was known as the Oculo-Photometer.[70] The principles underlying its construction[71] and operation are essentially the same as those in the other portable binocular cameras. It also may be used for photography of eye-movements while subjects are looking at distant objects or reading from the Metron-O-Scope. With the Ophthalm-O-Graph, however, a special attachment is used to obtain the best results in distance photography, because in sighting over the camera barrel the tendency is to raise the eyes so high that the reflection is from the eyeball below the cornea, resulting in a blurred record that has no value. A great many Ophthalm-O-Graphs have come to be used in the last few years by eye specialists in office practice, and by educational institutions where studies in reading are being carried on.

1935.—A small portable eye-movement camera was built at the University of Chicago under the direction of Dr. Buswell.[72]

[70] Referred to by Gates, *The Improvement of Reading*, pp. 353 and 390.

[71] Cf. diagram, p. 97. The Ophthalm-O-Graph is attached to an adjustable metal stand. The apparatus is fifty inches high, and is light enough in weight to be carried from place to place. The camera alone is twelve inches high, eleven inches wide, and twenty-seven inches long.

[72] An additional light unit, containing two bulbs, is attached to the top of the camera barrel, near the lens tubes, by a metal bar.

CHAPTER IV

TYPES OF BINOCULAR READING-GRAPHS

In the early studies of eye-movements by *objective methods* very few subjects were used in the experimental work, yet many of our educational theories and practices have been influenced decidedly by the conclusions drawn. Dearborn, using the corneal reflection method, made the first systematic study in 1906.[1] Until very recently most of the investigators using this method followed his example of photographing the movements of only one eye. A monocular eye-movement photograph shows the number of fixations, the number of regressive movements, and the speed of reading, but it reveals nothing concerning the *co-ordination of the eyes*.

Dodge and Cline were the first to make the observation that the eyes do not move together, necessarily, in the act of reading. In fact, they made the statement that "valuable practical as well as theoretical results may be expected from a quantitative study of binocular coordination."[2]

[1] Reported in *The Psychology of Reading*.

[2] Dodge and Cline, "The Angle Velocity of Eye-Movements," *Psychological Review*, VIII (March, 1901), 156.

McAllister[3] and Schmidt[4] also call attention to the lack of binocular co-ordination. In the case of some readers the eyes lack uniformity in starting each line, and in the interfixation movements, that is, the rate of movement is not the same in the two eyes, and they do not move in the same direction. It was not until 1933 that eye specialists began to realize the significance of eye-movement photography, and an increasing number are recognizing that a *binocular reading-graph is an essential part of any comprehensive eye examination.* Such a graph supplements the customary eye examination by providing objective information concerning the actual behavior of the eyes in near-point[5] work. Fusion[6] is co-ordinate with binocular single vision. Fusional conflicts which may result in inaccurate perception, and in turn influence reading ability, are often caused by muscular irregularities[7] and refractive errors. Besides showing the binocular co-ordination between the two eyes a binocular reading-graph indicates the

[3] Cloyd N. McAllister, "The Fixation of Points in the Visual Field," *Psychological Review Monograph Supplements*, VII (March, 1905), 17–53.

[4] Schmidt, *An Experimental Study in the Psychology of Reading*, pp. 85–125.

[5] Normal reading distance, twelve to sixteen inches.

[6] Cf. p. 234.

[7] Any unco-ordinated activity of the ocular muscles; cf. p. 155.

mechanical efficiency of the reader, in that it records *every* movement of the eyes as they follow the line of print or move from one line to the next. This type of information is invaluable in suggesting corrective procedures and in measuring the progress of remedial work. The reading-graphs presented in this chapter, all of which were recorded with a binocular camera, show some peculiar eye-movements that would not be apparent in a monocular graph.

A true record of eye behavior during the act of reading is obtained if bright beads of light are reflected from the two corneas and the relative movements of these reflections are photographed on a motion-picture film moving at an even speed. In the reading-graph so obtained the eye-stops, or fixations, are recorded as short vertical lines, the length of the line in each instance indicating the duration of the fixation. The return sweep, or movement of the eyes from the end of a line to the beginning of the next line, is shown as a line deviating slightly from the horizontal, according to the time involved in the movement and the co-ordination of the eyes. In the reading-graph the vertical lines which correspond to the fixations in a line of print form a double stairway, the number of steps depending on the number of fixations in the line. The right row of steps is the graph made by the left eye, and the left

row is the graph made by the right eye. Regressive movements are shown as backward steps to the left, after the line has been started, while non-regressive reading consists of a series of fixations progressing in sequence from left to right.

The study of a large number of reading-graphs secured in the experimental work described in Part IV furnishes convincing evidence that: (*a*) In many cases regressive movements are merely corrective adjustments, made because of inaccuracies in perception which are due to refractive errors or lack of oculo-motor control of the eyes, or both. The number of regressions, therefore, is probably an excellent index of accuracy of perception in cases where reading disability is due to visual anomalies. (*b*) The graph of an efficient reader will show relatively few fixations to the line of print, indicating a broad span of recognition. The fixations will be short, indicating a correspondingly short reaction time.[8] In a study of reading-graphs, then, it is the *number* of fixations, indicating the span of recognition and the *length* of the fixations, indicating the re-

[8] Miles A. Tinker and A. Frandsen, "Evaluation of Photographic Measures of Reading," *Journal of Educational Psychology*, XXV (February, 1934), 96–100.

Alvin C. Eurich, "The Reliability and Validity of Photographic Eye-Movement Records," *Journal of Educational Psychology*, XXIV (February, 1933), 118–22.

"Additional Data on the Reliability and Validity of Photographic Eye-Movement Records," *ibid.*, XXIV (May, 1933), 380–84.

action time, which reveal the maturity of the reading. (*c*) The type of reading material also influences the speed and efficiency of the reader. With all types of material, however, the speed of the rapid reader is greater proportionately than that of the slow reader under the same conditions.[9]

When the subject to be photographed is seated at the camera, and the necessary adjustments have been made, and the motor started, he is instructed to fixate, first at the left-hand dot on the camera card, which is directly above the beginning of the first line of print, and then at the right-hand dot, which is directly above the end of the first line. With the length of the line so determined in the graph it is relatively easy to project the record on to the printed material, and, by following the plainer of the two lines, to plot the fixations almost as accurately as can be done with a headline. In the early experimental work numerous reading-graphs were plotted in an attempt to locate correctly the position of the eye fixations on the reading material. Records taken with a large camera with a headline, as well as those taken with the small portable cameras, were used in this experimental work. It was decided that, because of the irregularities of eye behavior, the plotting of eye-movement records made with any camera is only relatively

[9] Dearborn, *The Psychology of Reading*, p. 118.

accurate.[10] Until a technique has been developed whereby the position of each fixation can be readily determined, little practical information beyond that obtained in research already completed can be gained by plotting. Irregularities in eye behavior, and differences between the visual axis and the optical axis[11] which may cause inaccuracies in plotting the position of fixation, however, do not affect certain types of work in which the eye-movements are not photographed in the act of reading.[12]

All the reading-graphs presented in this chapter, with the exception, perhaps, of those on Plate L, are typical of cases that may be found in any community. Some of them furnish evidence of extreme lack of binocular co-ordination. The significance of this objective information lies in the fact that a slight irregularity shown in the reading-graph may indicate a fusional conflict, which may be responsible, in a measure, for difficulties experienced by the sub-

[10] Miles A. Tinker, "Use and Limitations of Eye-Movement Measures of Reading," *Psychological Review*, XL (July, 1933), 382.

Gordon Nevin Rebert, "A Laboratory Study of the Reading of Formulas and Familiar Numerals," Doctor's dissertation, Department of Education, University of Chicago (1929), pp. 23–24.

[11] George E. Park, M.D., "The Precision Anglometer," *Archives of Ophthalmology*, XV (April, 1936), 703–9; "An Investigation of the Angular Relation of the Visual (Visierlinie) and Optic (Corneal) Axes of the Eye," *American Journal of Ophthalmology*, XIX (November, 1936), 967–75.

[12] Buswell, *How People Look at Pictures*.

PLATE XLVII

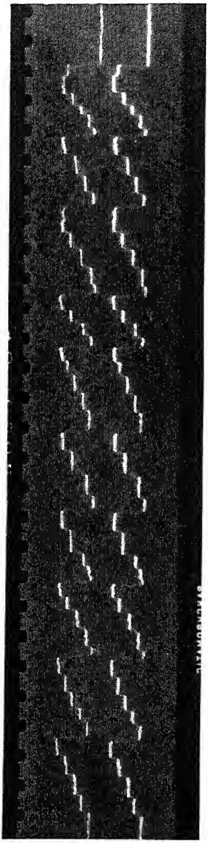


Fig. 1

READING-GRAPH OF HIGH-SCHOOL GIRL WHO MAKES EXCELLENT GRADES IN ALL SUBJECTS

The reading rate is 371.76 words per minute. In photographing a large group a number of students will be found whose reading is as efficient and even more rapid than the reading of this subject, but the graph is typical of a superior reader who has had no training in reading other than the routine instruction in the elementary school. The graph indicates that the eyes are well co-ordinated. In our schools little, if any, training is given to condition the rhythmical eye-movements shown here, and comparatively few students are capable of developing this type of reading on their own initiative.

PLATE XLVIII

Reading-Graph of Boy in Fifth Grade Whose Reading Rate is 20 Words per Minute, with Approximately 300 Fixations and 125 Regressions per 100 Words

This is a typical case of inefficient reading with disastrous results. The subject has failed to receive promotion three times, yet he has little difficulty in grasping and retaining subject matter that he hears discussed. He is easily discouraged with reading assignments. Unless remedial training is given and he is reconditioned to read properly, he will continue to be a problem case, or will drop out of school.

PLATE XLIX

FIG. 3

READING-GRAPH OF HIGH-SCHOOL SENIOR WHO HAS HAD TEN PERIODS OF PRISM-READING TRAINING*

The reading-rate is 649.41 words per minute, which is an improvement of 205.41 words per minute over her original rate. This is an excellent example of a superior student who, because of a convergence insufficiency, before training habitually read far below her capacity. The eye co-ordination and rhythm of the reading are very noticeable in the graph.

* Cf. chap. xii.

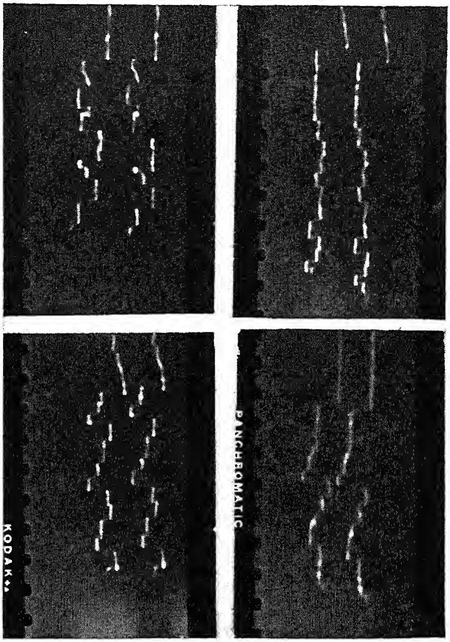


FIG. 4

FOUR GRAPHS SHOWING READING OF EIGHT-YEAR-OLD BOY WHO HAS ATTENDED SCHOOL FOUR YEARS AND IS IN HIGH SCHOOL

When his eye-movements were photographed, he was in the ninth grade but was carrying tenth-grade mathematics successfully. His eye-movements have been photographed thirteen different times, and all the records are somewhat similar to those shown above. He reads backward as well as forward, evidencing few of the characteristics usually associated with the reading process. The rate of reading has varied from 646.15 words per minute to 2202.53 words per minute. During one period of photography lasting 44.91 seconds he averaged 853.71 words per minute, with 100 per cent comprehension. At another time, for 9.8 seconds he averaged 1989.79 words per minute, with excellent comprehension. He evidently has an unusually large macular area* which enables him to read with what has been termed a "photographic" eye.

* Cf. p. 237, n. 14.

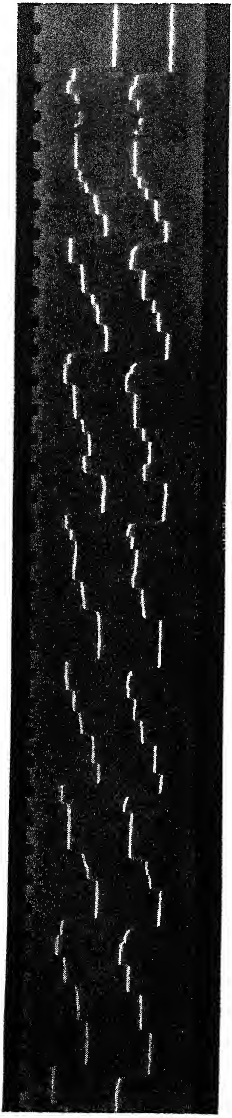


FIG. 5

READING-GRAPH OF A UNIVERSITY SENIOR

Overconvergence of the left eye is pronounced at the beginning of the first fixation in each line. The muscles relax during the fixation, and in the graph of the left eye the first fixation in each line is, therefore, an oblique rather than a vertical mark. The muscles continue to relax throughout the reading of the line, but the movements of the left eye are never co-ordinated with those of the right eye. This irregular activity is repeated in every line.

An irregularity of this type would probably tend to produce fatigue in prolonged reading. The reading rate is 232 words per minute, which is far below the norm for college level. By putting in extra time the subject has made an average of B in his university work, but he has been much handicapped by reading disability. Intelligence tests given in several university classes indicated that he had one of the lowest I.Q.'s in the group, but the scores may have been influenced in some degree by reading inefficiency.

READING-GRAPH OF HIGH-SCHOOL GIRL WHOSE EYE EXAMINATION INDICATED A REFRACTIVE CONDITION CALLING FOR A +1.00 SPHERE FOR EACH EYE

The graph shows that she overconverges at the beginning of each line, and as she does not see clearly at that instant, she makes a regression to get the meaning from the print. The reading rate is 141.96 words per minute, much too low for high-school level; consequently the subject must put forth a great deal of effort to keep up with the required reading.

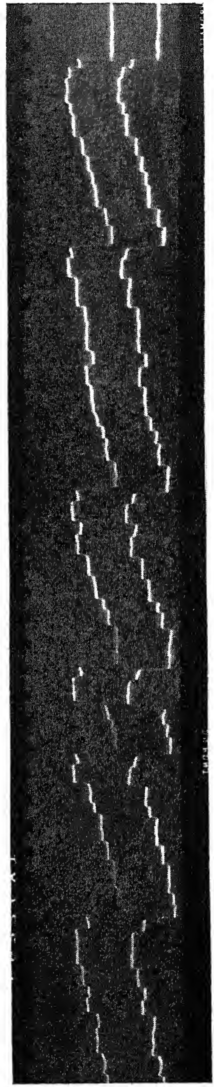


FIG. 6

PLATE LIII

Reading-Graph of Woman Who Has Unusual Amount of Astigmatism* in Each Eye

There is evidence of progressive convergence as she continues to read, and this phenomenon is present whether she is reading with glasses or without them.

* Cf. p. 163, n. 6.

Reading-Graph of a High-School Junior Whose Left Eye Is Amblyopic, Vision 20–200 with or without Lenses. He Is a Good Reader, although He Uses Only One Eye.

This student has a slight convergent squint. Underconvergence is particularly noticeable at the beginning of each fixation. At the beginning of the first fixation in each line the graph of the left eye approaches that of the right eye, forming a narrow loop.

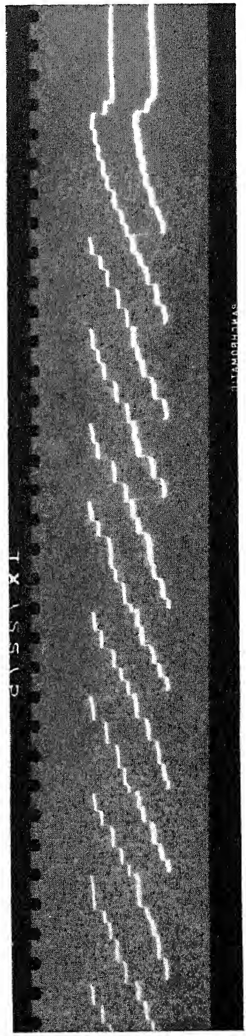


Fig. 8

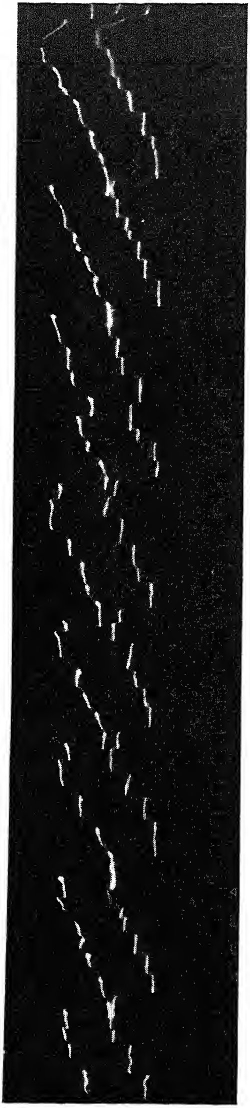


FIG. 9

READING-GRAPH OF SUBJECT WITH HYPER-EXOPHORIA

On the return sweep the right eye diverges and curves up, and there is no co-ordination between the movements of the two eyes, one moving more or less vertically while the other moves horizontally.

The left eye overconverges at the beginning of each line, as shown by the points in the graph at the beginning of the first fixation. Evidently in many instances perception is inaccurate on the first fixation, as the second fixation is a regressive movement for the purpose of re-reading. Reading, necessarily, is a laborious task for this subject. His school work is poor, especially in subject requiring careful eye-movements. In mathematics, for instance, he has repeated courses two or three times.

Reading-Graph of High-School Girl Who Suffers from Fusional Conflict

She is able to maintain binocular single vision for a short time if she holds the reading material far enough from the eyes, but at the near-point the right eye tends to converge and she sees double. She can always restore binocular single vision by glancing at a distant object, but after she reads for a few minutes, diplopia recurs. As this difficulty becomes more pronounced from year to year, her school work becomes more difficult. This is an excellent example of the compensatory behavior of the eyes in an attempt to avoid a fusional conflict.

Fig. 10

PLATE LVII

Fig. 11

Fig. 12

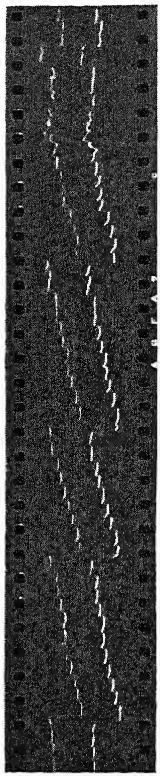


Fig. 13

Fig. 14

Examples of Eye-Movements in Nystagmus

With these subjects reading is naturally a laborious process

READING-GRAPHS OF SUBJECT WITH AND WITHOUT LENSES

In Figure 15, where no lenses were worn, there is evidence that the left eye is used very little in the reading process. This is especially noticeable in the third, fourth, and fifth lines, where the left eye obviously underconverges.

In Figure 16, where lenses are worn, there is evidence that an attempt is made to use the left eye. This is particularly noticeable at the beginning of each line and the beginning of each fixation. This excessive activity of the left eye, as shown in Figure 16, would account in a measure for the discomfort which the subject experiences when wearing lenses.

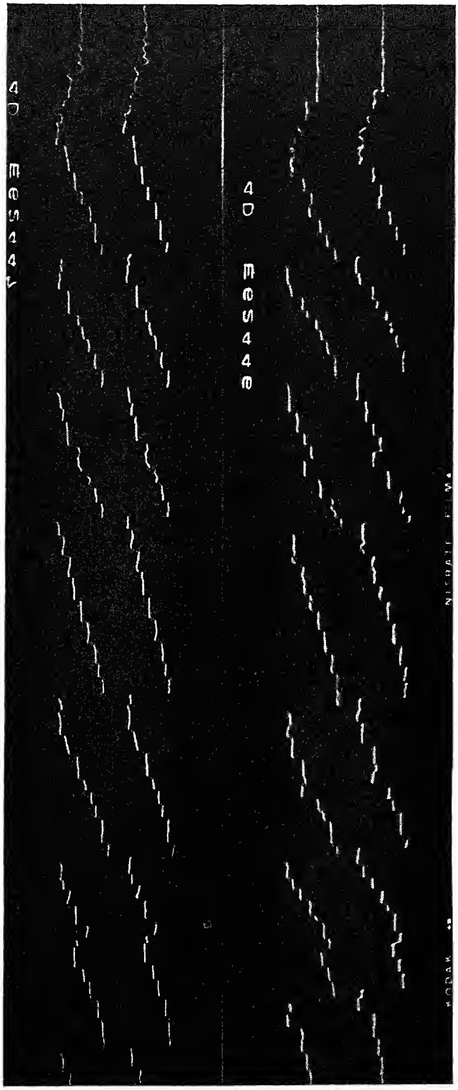


FIG. 15 FIG. 16

PLATE LIX

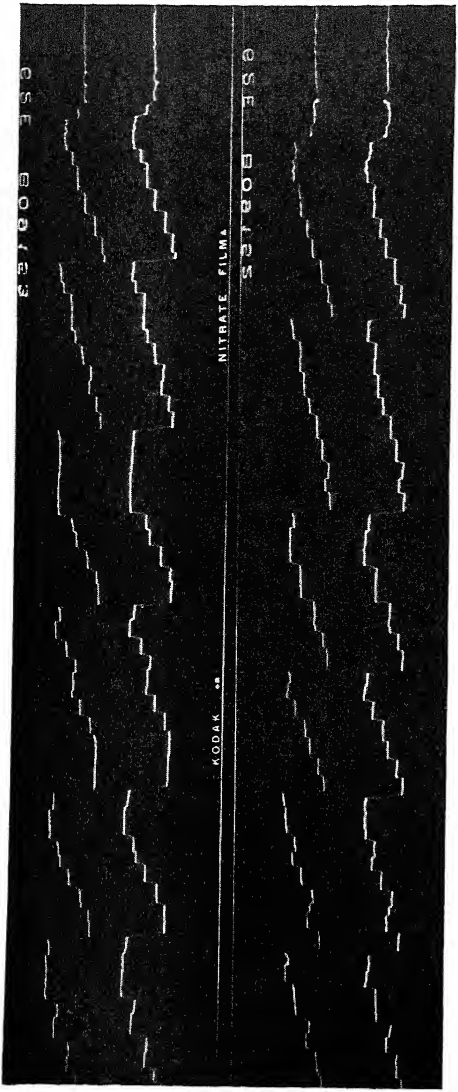


FIG. 17 FIG. 18

READING-GRAPHS OF SUBJECT WITH AND WITHOUT LENSES

It is apparent that the two eyes are not co-ordinated in the interfixation movements. The right eye makes a downward sweep while the left eye moves more or less horizontally. A careful comparison of the graphs indicates that this activity is more pronounced in reading with lenses. The subject prefers to read without lenses, as he is more comfortable.

Comparison of the two graphs indicates also that there is little difference in the reading efficiency of the subject, with or without lenses, as far as the mechanical aspects of reading are concerned.

ject in reading. At the same time, he may be totally unaware of the existence of an abnormal condition.

The reading-graph not only makes possible the study of binocular co-ordination, but also indicates the number of fixations and regressions, and the reading time. From these data it is possible to compute the reading speed, the span of recognition—which is the most important factor in rapid reading, and the reaction time—that is, the time required to fixate and perceive and comprehend the meaning of the printed symbol.

Table I was compiled to meet the need of educators and eye specialists who recognized the desirability of having a table of norms for the various grade levels. The norms introduced in the first line of each item are based upon data from the reading-graphs of over two thousand subjects, at different levels of instruction, selected at random from various schools and classes. The figures in the second line of each item represent data from the reading-graphs of subjects trained with the Metron-O-Scope, and indicate averages obtained at the various grade levels. It is realized that standards, to be valid, must be based on data secured from a very large number of subjects and selected from many types of situations; and as further data are accumulated, the figures in Table I will be revised.

Meantime, these norms furnish data comparable with that secured in surveys, and teachers carrying on corrective procedures with the Metron-O-Scope at the grade levels represented in the

TABLE I*

EYE-MOVEMENT NORMS AND AVERAGES

Grade	High 1st	2d	3d	4th	5th	6th	7th	High School	College
Fixations per 100 words									
norms...	250	200	175	140	125	120	115	93	80
Averages..	190	150	137	115	100	98	95	88	70
Regressions per 100 words									
norms...	60	50	40	30	25	23	21	17	10
Averages..	40	32	30	25	20	16	15	13	8
Words per minute									
norms...	55	90	115	168	190	200	210	295	325
Averages..	90	130	160	198	225	250	280	350	425

* All the data are based on silent reading of graded material.

The norms are based on the reading-graphs of over two thousand students trained by traditional methods.

The averages are based on the reading-graphs of a smaller group who received training in controlled reading with the Metron-O-Scope. They suggest the attainments to be expected at the various educational levels.

To use the table, compute data of film record and compare the number of fixations and regressions and the speed with the appropriate grade level. For instance, using the first line of figures in each item—if the subject's reading-rate is 200 words per minute, he is at sixth-grade level in terms of speed. If he makes 110 fixations in reading 100 words, he is better than seventh grade in terms of fixations; and if he makes 17 regressions in reading 100 words, he is average for high-school level in that respect.

table have objective data which indicate the type of performance that might be expected. With the appropriate norm, and the average expectation from Metron-O-Scopic training, the

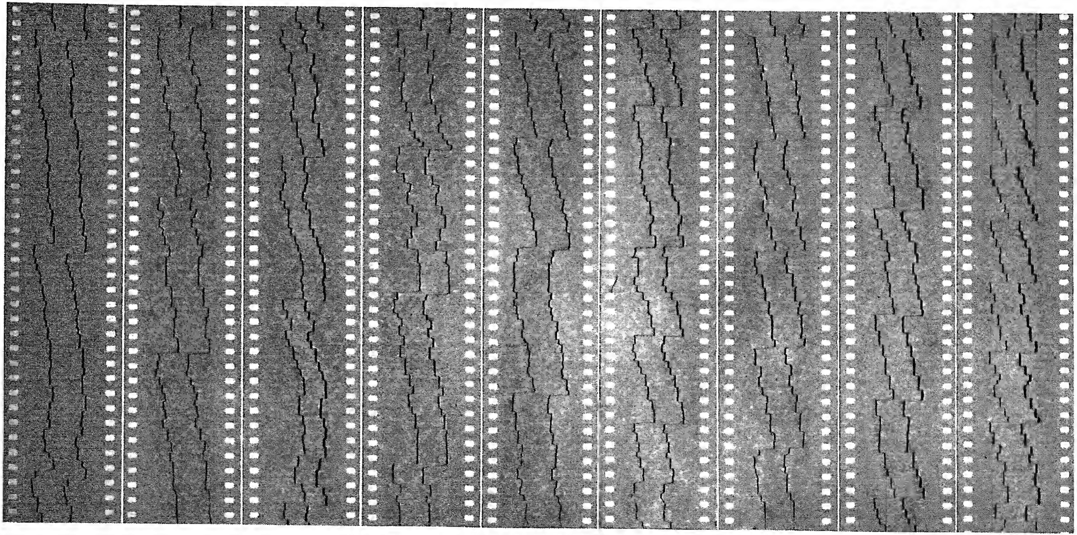
teacher or the eye specialist can adapt corrective measures to meet the need of the individual case.

It is agreed that the purpose of the reading and the nature of the material read influence the reading pattern, so that the findings from the reading-graphs taken from time to time are not constants. With all the data in the individual case, however, it is possible to predict with more or less certainty the performance of the subject in any reading situation.

The reading-graph is particularly valuable in diagnostic work because it is the only device that furnishes objective information concerning the maturity of the reading habit, or the functional efficiency of the subject in the reading situation.

The reading-graphs shown on Plate LX illustrate characteristic eye-movements of readers at the various grade levels, and indicate the maturation of the reading habit.

PLATE LX



Grade I Grade II Grade III Grade IV Grade V Grade VI Grade VII High School College

MATURATION OF THE READING HABIT

The change in the eye habit of the average pupil, as he advances academically, is characterized by: (*a*) Fewer fixations to the line, indicating a broadening span of recognition; (*b*) shorter fixations, indicating more rapid reaction to the printed symbol, and (*c*) a more rhythmical pattern resulting from more precise lateral control, fewer regressive movements or corrective adjustments for rereading, and greater uniformity in the length of the fixations.

PART III

SPECIAL TECHNIQUES AND APPARATUS FOR CONTROLLED READING

CHAPTER V

ESSENTIALS OF A COMPREHENSIVE READING PROGRAM

The consensus of opinion seems to be that degrees of reading efficiency determine to a great extent the success or failure of children in the public schools.[1] This statement finds support in the fact that numerous cases of failure are noted among those who have sufficient intelligence to meet the ordinary school requirements but find the assigned work impossible because they are poor readers. When proper remedial work is given, many of these cases show remarkable improvement in reading efficiency and are able then to carry a normal school load. There is a graded series of reading abilities, ranging from the poorest to the most efficient reader, and this series is not determined primarily by intelligence, for

[1] Harry J. Baker and Bernice Leland, *In Behalf of Non-readers*. Bloomington, Ill.: Public School Publishing Co., 1934.

National Education Association (Research Division), *Better Reading Instruction*. Research Bulletin of the National Education Association, XIII (November, 1935), 273–325.

Gates, *The Improvement of Reading*, pp. 1–5.

Charles H. Judd and others, *Reading: Its Nature and Development*. Supplementary Educational Monographs, No. 10. Chicago: University of Chicago, 1918.

tests show that the child with a high I.Q. is not necessarily a good reader. It is recognized, however, that dull children[2] generally experience greater difficulty with reading than do those of higher intelligence. In accounting for the wide variability in reading performance the compensatory capacity of the individual must be taken into consideration. Probably every child has some defect that *might* influence his general efficiency in reading, but, if he is able to make suitable compensatory reactions, the teacher is usually unaware of the defect unless it is revealed by special tests. Many times, in observing two students who seem to have about the same mental ability and the same physiological deficiencies, it is found that one apparently has no difficulty in making adjustments while the other is a failure so far as school work is concerned.[3] It may be assumed, further, that there is a physiological limit to the individual's capacity to compensate for any defect. So long as the defect remains within his limit of compensation, he may progress fairly well, but as soon as this limit is reached he

[2] Gates, *op. cit.*, p. 373.

Clarence R. Stone, "Case Studies in Reading and Deductions on Retardation," *Elementary School Journal*, XXXIV (September, 1933), 50–57.

[3] Marion Monroe, "Diagnosis and Treatment of Reading Disabilities," *Educational Diagnosis*, pp. 201–28. Thirty-fourth Yearbook of the National Society for the Study of Education. Bloomington, Ill.: Public School Publishing Co., 1935.

becomes identified with the group designated as "problem cases."

Elementary school teachers are not alone in their concern over this reading problem; teachers in the junior high school, the senior high school, and the college[4] realize that reading disability is a major deficiency among their students. Many students who have reached high-school and even college level find it impossible to cover the required work because they cannot read comprehensively, never having developed the mechanical skill that would enable them to grasp thought units. Reading is the most used of all the arts and consequently deserves the maximum amount of attention, not only in the elementary school but even through the high school and university. It would be well for every college

[4] Mabelle B. Blake and Walter F. Dearborn, "The Improvement of Reading Habits," *Journal of Higher Education*, VI (February, 1935), 85–88.

William S. Gray, "The Nature and Extent of Reading Deficiencies among College Students," an address delivered at the Joint Meeting of the National Society of College Teachers of Education and the American Educational Research Association, February 25, 1936. Sixty-sixth Annual Convention of the Department of Superintendence of the National Education Association, St. Louis, Mo., February 22–27, 1936.

Frank W. Parr and Claude L. Nemsek, "The Inefficient Silent Reader in College," *Peabody Journal of Education*, VII (March, 1930), 299–303.

James Maurice McCallister, *Remedial and Corrective Instruction in Reading*, pp. 3–14. New York: D. Appleton-Century Co., 1926.

and university to offer its students an opportunity to increase their reading efficiency, since this is the one skill that they are to use daily throughout life. Teachers in training[5] likewise should be given an opportunity to take a course in which they themselves learn to read more efficiently. A course of this nature not only would give the teacher firsthand information concerning the terminology, methods, and apparatus used in this field, but, in turn would tend to stimulate independent thinking[6] and research in connection with the everyday problems of the classroom. Teacher-training institutions which have undertaken experimental work of this nature are finding that their students are very enthusiastic about such courses. Equipped with specialized training in diagnostic, prognostic, teaching, and corrective work, the teacher finds her value in the school system enhanced in an appreciable degree. She is able to co-operate more effectively in a corrective program, in addition to carrying on the teaching routine in the classroom.

It is recognized that, because of the time element, the classroom teacher of reading must have at her disposal a technique or method which not

[5] W. D. Armentrout, "Professional Preparation of Elementary Teachers," *Education*, XLV (March, 1925), 385–91.

[6] Charles H. Judd, "Raising the Level of the Education of Teachers," *School Review*, XLIV (April, 1936), 257–67.

only provides for rapid, adequate diagnosis, but also furnishes a highly motivated and effective teaching procedure. This technique must include provision for corrective work and must be adapted easily and with slight variation to students of different age levels. Such a technique must be simple, suitable for both silent and oral reading, and must fit into any school situation.

In the reading program it is necessary to maintain a proper balance between oral[7] and silent reading. Both are vitally important to the welfare of the child, and neither should be emphasized to the exclusion of the other. Since the child, later in his experience, is to use silent reading almost constantly, much time should be devoted to the development of rapid, accurate, comprehensive silent reading. On the other hand, oral reading permits the beginner to bring into

[7] Clarence T. Gray, "The Purposes and Values of Oral Reading in the Intermediate and Upper Grades of the Elementary School," *Elementary School Journal*, XXIX (January, 1929), 335–43.

Vera Alice Paul, *Present Trends of Thought on Oral Reading*. College of Education Series, No. 21. University of Iowa Extension Bulletin, No. 299. Iowa City, Iowa: University of Iowa, 1932.

Mary E. Pennell and Alice M. Cusack, *The Teaching of Reading for Better Living*, pp. 26–40. New York: Houghton Mifflin Co., 1935.

William S. Gray, "The Place of Oral Reading in an Improved Program of Reading," *Elementary School Journal*, XXXVI (March, 1936), 517–26.

play his own associations with the various words which he vocalizes, thus making more vivid his reaction to the new information acquired. As he progresses, new words are associated with the early experiences, and his total mental process of association and reasoning becomes more complex. This development[8] of complex associations permits the reader, as he matures, to extract ideas from the printed page. There is no arbitrary method of determining just what the ratio should be between the time spent in oral and in silent reading. It will vary with the requirements of different classes and different age levels. It is certain, however, that the greater part of the reading period in the first two grades should be devoted to oral reading. While it is true, perhaps, that definite training in oral reading should not extend beyond the third or fourth grade, it has been found very valuable in carrying on various types of remedial work, even with college students.

In dealing with reading disabilities several writers have presented excellent summaries[9] of

[8] Guy T. Buswell, "The Relationship between Eye-Perception and Voice-Response in Reading," *Journal of Educational Research*, XII (April, 1921), 217–27.

[9] Emmett A. Betts, "Reading Disability Correlates," *Education*, LVI (September, 1935), 18–24.

Harry A. Greene. *A Remedial Program for Silent Reading in the High School.* Iowa University Extension Division Bulletin, No. 240. Iowa City, Iowa: University of Iowa, 1929.

Gerald A. Yoakam, *Reading and Study: More Effective Study*

the various factors which might contribute to reading inefficiency. Perhaps the large number of these stated defects, listed as a result of breaking down reading deficiencies into their component parts, has tended to bewilder the classroom teacher. Regardless of the number and types of deficiencies exhibited by the individual, he must be considered as a unit personality;[10] for children may compensate differently for the same type of defect, and such possible variability from pupil to pupil must be taken into account by those who attempt to teach and carry on corrective work in reading. It is certain that the same stereotyped procedure cannot take care of all individual differences, and it is necessary, therefore, for the classroom teacher to have sufficient information concerning all the pupils, and especially those exhibiting defects, to admit of intelligent variation in the use of any of the numerous methods or techniques which may be employed.

Ideal conditions in a school would permit the reading teacher to send her problem cases to a

---

through Better Reading Habits, pp. 443–45. New York: Macmillan Co., 1928.

Marion Monroe, *Children Who Cannot Read*, pp. 79–110.

[10] Clifford Woody, "Diagnostic and Remedial Instruction in Reading Factors Conditioning the Reading Process," *Seventeenth Annual Conference on Educational Measurements*, pp. 85–101. Bulletin of the School of Education, Indiana University, Vol. VI, No. 5. Bloomington, Ind.: Bureau of Co-operative Research, Indiana University, 1930.

clinic, where they would be given a series of mental and reading tests by a trained psychologist, and a thorough physical examination. In addition a complete eye examination would be made by a competent eye specialist. Either the visual or the reading examination would include a record of eye-movements in the act of reading.

No single reading test is as effective as a reading-graph in getting at the root of reading disability, because this graph is the only means of obtaining *objective information regarding symptoms* which indicate the degree of reading maturity.[11] The reader is generally unaware of the way in which his eyes function as they follow the lines of print. The fact that he has little voluntary control[12] over this activity increases the validity of the reading-graph as a diagnostic test. No other test furnishes *objective* information concerning the *way* in which the reading is done.

A photographic record of the mechanical activity of the eyes in the act of reading permits comparison of the functional efficiency of pupils

[11] Guy T. Buswell, *Fundamental Reading Habits: A Study of Their Development*, p. 8. Supplementary Educational Monographs, No. 21. Chicago: University of Chicago, 1922.

Miles A. Tinker, "Use and Limitations of Eye-Movement Measures of Reading," *Psychological Review*, XL (July, 1933), 383.

[12] Buswell, *Fundamental Reading Habits*, pp. 7–10.

M. D. Vernon, "The Relationship of Subjective Experience to the Performance of Eye-Movements," *British Journal of Psychology (General Section)*, XX (October, 1929), 161–72.

reading the same material under the same conditions, and also of the performances of the same individual from time to time.

Reports of the examinations, along with copies of the reading-graph, would be sent to the reading teacher who requested the examination. After abnormal physical conditions have been taken care of, and eye defects corrected—either by lenses or eye-muscle exercises, or both—the teacher is in a position to direct a vigorous teaching or corrective reading program.

This program, as outlined, can be carried out successfully in almost any school system. Usually there are teachers with sufficient psychological training to enable them to carry out a testing program, and almost every community can obtain the services of physicians and eye specialists who are willing to co-operate in a definite, comprehensive plan which concerns the welfare of the school population. Where the above program is not practicable at the present time, the classroom teacher must carry on the preliminary diagnostic work. If she has had courses in an institution with a modern reading clinic, she will be familiar with the use of the latest techniques and devices for carrying on this work. A teacher without this specialized training can supplement her theoretical knowledge of the subject by a few hours of training in the use of such techniques and devices. Sufficient information can be se-

cured in this way to enable her to carry out any type of reading-testing program, to screen out[13] cases requiring further examination by an eye specialist, and to locate those needing other types of service not available in the classroom. The public schools today are spending large sums in reteaching and remedial work, and very few schools are satisfied with the results obtained with methods now in use. There has never been so much time spent in the study of a single school problem as has been devoted to the improvement of reading methods in the last few years. Parents and school officials alike welcome new techniques which promise greater efficiency with the same expenditure of time and money.

Teachers on the whole are interested not only in proper diagnosis of reading deficiencies but also in ways (*a*) to motivate the child's interest in both the learning and the drill situations in-

[13] J. H. Berkowitz, *The Eyesight of School Children.* U.S. Bureau of Education, Bulletin, 1919, No. 65, pp. 34–38. Washington: Government Printing Office, 1920.

Beatrice McLeod, *Teachers' Problems with Exceptional Children,* I: *Blind and Partially Seeing Children.* U.S. Bureau of Education, Pamphlet No. 40. Washington: Government Printing Office, 1933.

James F. Rogers, M.D., *What Every Teacher Should Know about the Physical Condition of Her Pupils.* U.S. Bureau of Education, No. 18. Washington: Government Printing Office, 1924.

Conserving the Sight of School Children, p. 28. A report of the Joint Committee on Health Problems in Education, Publication 6. New York: National Society for the Prevention of Blindness, 1935.

volved in the teaching of reading, (*b*) to control the eye-movements in reading so as to condition accurate, co-ordinated responses while following the line of print, and (*c*) to increase the reading-rate without decreasing comprehension. The experimental data and the general discussion present an effective method for dealing with these problems.

CHAPTER VI

SPECIAL TECHNIQUES IN TEACHING AND REMEDIAL READING PROGRAMS AND THEIR APPLICATION

The first tangible technique for controlled reading has been developed in connection with the Metron-O-Scope.[1] This technique is adapted to classroom instruction, including teaching and remedial reading, at all age levels, and with either individuals or groups. Prism-reading,[2] a specific type of controlled reading in which the subject reads through prisms the material presented in the Metron-O-Scope, provides the eye specialist with a method not only for conditioning eye muscular co-ordination, necessary in many cases for comfortable vision, but also for establishing a precision of eye control in reading which in some types of reading disability cannot be secured by any other means.

Reading is not merely a pacing of eye-movements, a mechanical process. The very fact that comprehension is checked is a recognition that

[1] Cf. pictures, pp. 143–46 and 148. The Junior Metron-O-Scope, shown on pp. 147, 274, differs in no way except size from the larger model. It was built for use in training individuals in the classroom, the laboratory, or the office where space is limited.

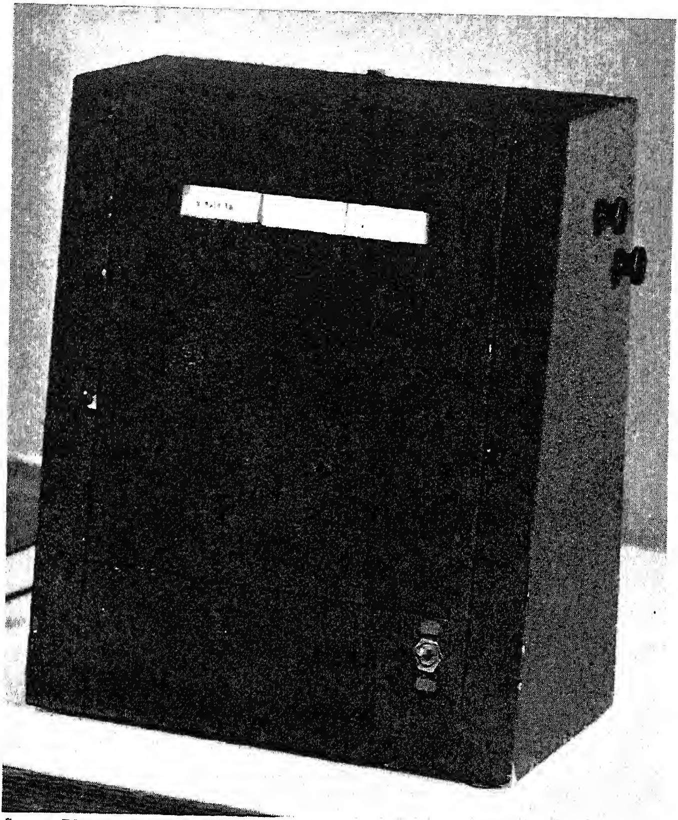
[2] Cf. chap. xii.

Courtesy Educational Laboratories, Inc.

FIRST METRON-O-SCOPE, ORIGINALLY KNOWN AS THE SYNCHROPTISCOPE

Built by Carl C. Taylor, Educational Laboratories, Inc., Brownwood, Texas.

PLATE LXIII

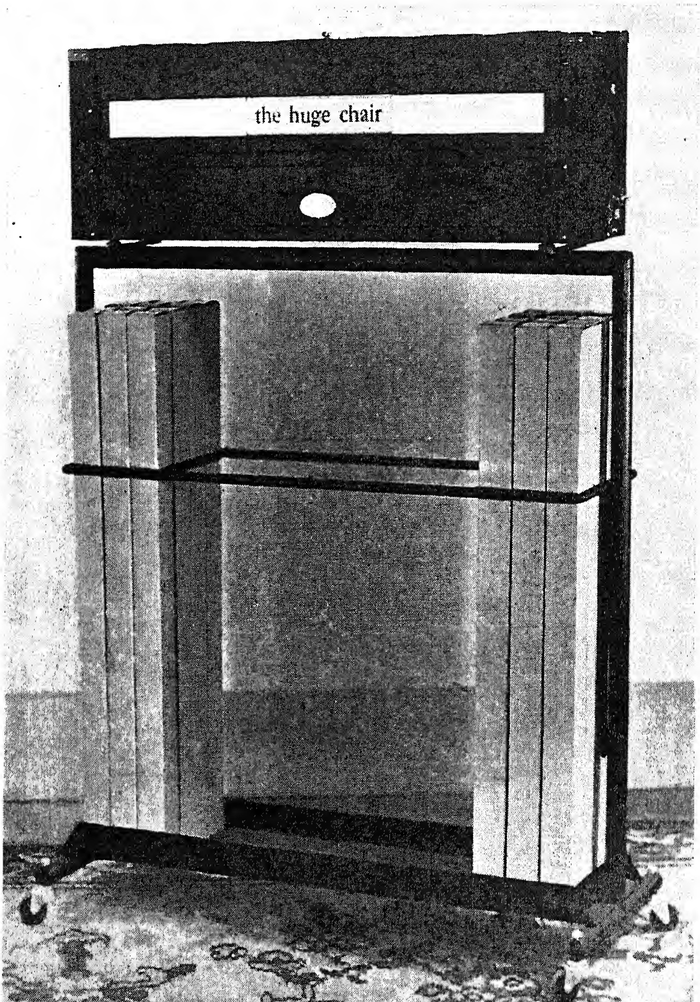


Courtesy Educational Laboratories, Inc.

SMALL METRON-O-SCOPE BUILT BY CARL C. TAYLOR AND JAMES Y. TAYLOR, EDUCATIONAL LABORATORIES, INC., BROWNWOOD, TEXAS, FOR USE IN FRONT OF THE LARGE EYE-MOVEMENT CAMERA IN THE EDUCATIONAL PSYCHOLOGY LABORATORY AT THE UNIVERSITY OF TEXAS.

This instrument was used in the first experimental work in controlled reading. The reading material was typewritten on the rolls and the shutters were operated by solenoids. The front of the case was about 10 inches long and 11 inches high.

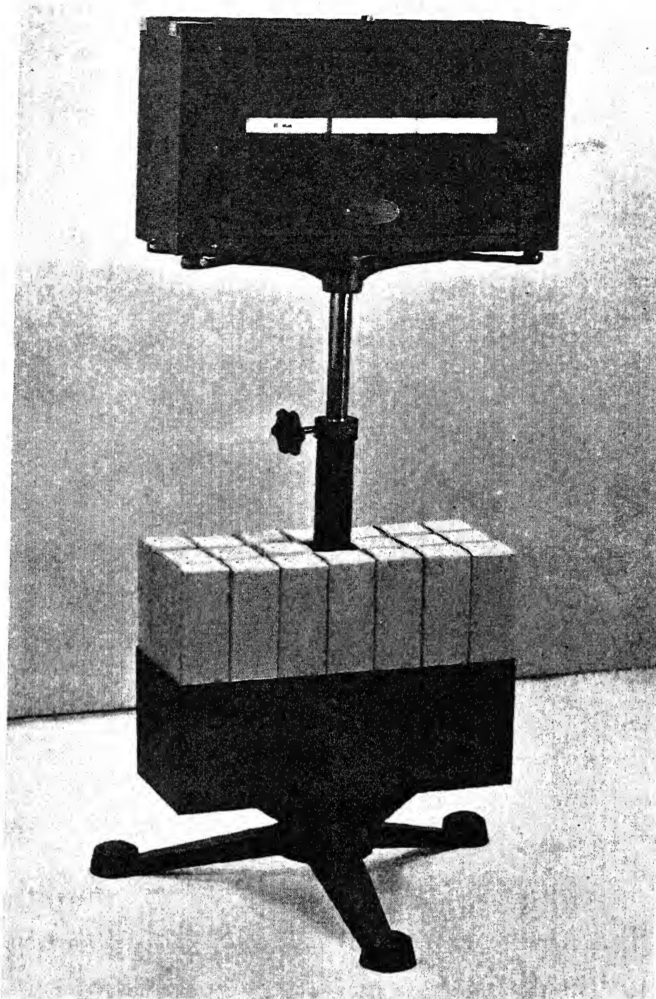
PLATE LXIV



Courtesy American Optical Company

THIRD MODEL OF THE SENIOR METRON-O-SCOPE

PLATE LXV



Courtesy American Optical Co.

JUNIOR METRON-O-SCOPE

Used for individual instruction and in office practice for prism-reading.

PLATE LXVI

Courtesy American Optical Company

THE SENIOR METRON-O-SCOPE NOW IN GENERAL USE

the organism is considered as a functional unit. Any technique to improve reading, then, must condition the whole organism to rapid, accurate perception and response to the printed page. It is generally found that rapid readers, who are accurate in comprehending the material read, have a mechanical skill in reading, as indicated by eye-movement photographs, far superior to that of inefficient readers. The fundamental idea, then, is *to develop the mechanical and interpretative processes simultaneously.*

The eyes are only receptors, directed toward environmental stimuli by the brain in such way that the attention value on the retinas is adequate for accurate perception. The brain "sees," so to speak. In binocular single vision the organism receives stimulation of the retinas, neural impulses are sent to the brain, fusion takes place, and implicit or overt responses are made. Controlled reading is, therefore, the quickening of a complicated process involving numerous functions which must be properly co-ordinated in each organism for rapidity of response during the act of reading.

Cattell introduced the short-exposure technique for studying reaction time and the span of recognition into this country in 1885–86. Several studies had been made with the tachistoscope in Europe in the preceding half-century, but Cat-

tell's experiments[3] were probably the first related directly to the study of reading problems. He found that there is a natural tendency to perceive words and phrases as wholes rather than in their component parts. It is only natural that educators interested in teaching and remedial work in reading should attempt to utilize this technique in various ways to improve classroom instruction, and to study reading problems in the laboratory. The primary object in the early studies of short exposure was to broaden the span of recognition and quicken the reaction to print. A number of writers[4] who have made important

[3] "The Time It Takes To See and Name Objects," *Mind*, XI (January, 1886), 63–65.

"The Inertia of the Eye and Brain," *Brain*, VIII (October, 1885), 295–312.

[4] Huey, *The Psychology and Pedagogy of Reading*, pp. 51–116.

C. T. Gray, *Types of Reading Ability*, pp. 1–8, 123–46, 157–60.

Schmidt, *An Experimental Study in the Psychology of Reading*, pp. 15–19.

John A. O'Brien, *Silent Reading*, pp. 3–4, 49–63, 126–28, 273.

J. V. Breitwieser, "Training for Rapid Reading," *Application of Psychology to Education*, pp. 15–17. Research Studies, 4, 5, 6, 7. Berkeley, Calif.: Bureau of Research in Education, University of California, 1922.

Buswell, *Fundamental Reading Habits*, pp. 138–48.

Miles A. Tinker, "How Formulae Are Read," *American Journal of Psychology*, XL (July, 1928), 476–83.

Clarence T. Gray, *Deficiencies in Reading Ability*, pp. 80–111.

Nancy Newell, "For Non-readers in Distress," *Elementary School Journal*, XXXI (November, 1931), 191–93.

M. D. Vernon, *The Experimental Study of Reading*, pp. 122–29.

contributions in this field of research have summarized the earlier studies.

Along with this type of presentation there developed classroom practices designed to control the reader's eyes in rhythmical, left-to-right movement and condition all accurate return sweep. Dearborn[5] is the first to suggest the possibility that the reader may be trained to a series of motor habits which will enable him to choose the two or three most advantageous positions for pauses in a line of print, and so to read in a more-or-less rhythmical fashion from one point of vantage to another. For a number of years teachers have attempted to control the mechanical process in reading, but they have been hampered by lack of proper instrumentation. Nevertheless, they have made some progress with such techniques as holding a ruler under the line, slipping a card with an oblong slot in it along the line of print so that only one section is displayed at a time, grouping words in thought units and spacing these units, using a pointer, placing indicated eye-stops under the line of print, pressure reading, and various types of tapping and metronomic exercises. Controlled reading with the Metron-O-Scope combines all the ideas underlying (1) short exposure as a means of broadening the span of recognition and reducing the reaction time, and (2) these classroom methods for

[5] *Psychology of Reading*, p. 12.

conditioning an efficient eye habit in reading. The triple-exposure feature directs and controls the eyes in a rhythmical left-to-right movement, The controlled motion also conditions accurate return sweeps, and, as the material in each opening is obscured as soon as it has been read, regressive movements are discouraged. All experimentation in the field of reading has shown the desirability of *controlled* reading as a teaching technique, during the period of initial instruction, and as a corrective technique at higher levels, that is—*reading in which the mechanical process is directed and co-ordinated with the interpretative process while the span of recognition is being broadened.*

Briefly described, the Metron-O-Scope is a triple-shutter tachistoscope.[6] A Universal Dumore motor[7] with a gear reduction of 50 to 1 moves both the roll of reading material and the shutters,[8] but the mechanism is so arranged that the roll and the shutters may be operated separately.

[6] Unless otherwise stated, the description refers to model shown on p. 148.

[7] The original instrument, shown on p. 143, was driven by a spring motor from a phonograph. The second model (p. 144). which was larger, had a small electric motor, also taken from a phonograph. A Universal Dumore motor was used in the third model, p. 146, but the motor did not operate unless there was a roll in the instrument. In all models the motor is housed in the case.

[8] "A," "B," and "C" in picture, p. 144. When "C" closes, "A" opens automatically, exposing the beginning of a new line.

The shutters operate on a system of cams. Any shutter can be shut and locked independently.[9] When all the shutters are unlocked, they open and close intermittently, in a left-to-right sequence.

A control switch[10] enables the operator to make the following adjustments: (*a*) one left-to-right operation of the shutters while a line of print is exposed, (*b*) *three* left-to-right operations of the shutters while a line of print is exposed, (*c*) continuous operation of the shutters while the roll remains stationary, (*d*) continuous unwinding of the roll in an unspaced movement, and (*e*) continuous re-winding of the roll in an unspaced movement.

The roll is spaced automatically by means of an electric contact roller unit and a series of small holes near the right-hand margin of the paper roll.[11] If the control switch is set at Space 1

[9] In the model shown on p. 148 each shutter is locked and unlocked by means of a button on the outside of the case door, but in all other models the shutters are adjusted by hand, from the inside of the case.

[10] On all other models the motor is started and stopped by means of a small switch on the end of the case. A separate button takes care of the two adjustments: (1) the regular exposure of a new line at each spacing of the roll, and (2) complete detachment, the shutters operating while the roll remains stationary.

[11] In all other models the spacing is controlled by a star gear at the end of the spacing roller. At each movement of the spacing mechanism the paper is fed between the spacing roller and a small pressure roller attached to the framework, in the center of

on the dial (*a*) when the roll is inserted, (*b*) after the roll has been reversed, or (*c*) after it has been wound continuously, the roll slips into place automatically, so that the printed line is exposed in the proper position in the windows.

The exposure time, or speed of the presentation, depends on the speed of the instrument,[12] which is regulated by setting the speed dial[13] at the appropriate point. The number of words presented in a line depends on the grade level and nature of the reading material. In the story rolls the number closely approximates the number of words per line in a textbook of the same grade level.

The reading rolls are inserted in the case in much the same way that music rolls are inserted in a player piano. They vary in length. Many are long enough to carry several short stories or selections. When all the material on the roll has been presented, the spacing mechanism stops

---

the top of the case. The action is thus similar to that in a clothes wringer.

The roll action is unspaced when the control switch is set at either "Continuous" or "Re-wind."

[12] In early models the speed ranged from about 90 to 240 words per minute. All the new instruments have a range of from 15 to 50 *lines* per minute.

[13] The speed dial is connected with an electric governor attached to the motor.

automatically. To re-wind the roll, the control switch is set at "Re-wind."[14]

From the discussion it is seen that the Metron-O-Scope is versatile and lends itself to all sorts of teaching and drill in the classroom. Any type of printed material or pictures may be presented on the rolls. The shutter combinations enable the teacher to present this material in a great variety of ways, not only for teaching, drilling, and testing, but for corrective reading of all types[15] in cases of reading disability. The instrument permits adequate control of the total reading situation, and yet requires very little attention on the part of the operator, unless the procedure is to be varied during the presentation of a roll.

The data obtained in the experimental work with the Metron-O-Scope indicate that controlled reading develops the accurate mechanical adjustments of the eyes which are essential to rapid reading. By eliminating the periods of confusion which result from unco-ordinated eye activities—inequalities in duration of fixations, lack of lateral control, excessive number of fixations and regressions, probably due to narrow span of recognition, and irregularities of

[14] In other models the re-winding mechanism is set in motion by opening the case door.

[15] Miles A. Tinker, "Remedial Methods for Non-readers," *School and Society*, XL (October 20, 1934), 524–26.

binocular fixation—it aids the child in concentrating on the interpretation of the material under consideration. The tendency is not only to reduce the *reaction time* but to broaden the *recognition span*. It is true that the span of recognition is dependent, to a large extent, on the physiological structure of the eyes, and the majority of subjects cannot, therefore, be taught to read a line of print with just three fixations. On the other hand, experiments show that the breaking of the line into three exposures tends to broaden the span of recognition, which in turn tends to reduce the number of necessary fixations and regressions.

Many of the problems of maturation or reading readiness[16] probably would be eliminated if children were taught how to control[17] and coordinate their eye-movements before the actual reading process is undertaken. The child in the primary grades has not yet learned to co-ordinate

[16] Linda Yageman, "Should All First-Grade Children Be Given a Reading Program?" *California Journal of Elementary Education*, III (February, 1935), 158–64.

Points of View on the Problem of Reading Readiness, Reading Readiness Committee of the International Kindergarten Union, 1929–30. Washington: Association for Childhood Education, 1931.

Buswell, *op. cit.*, pp. 58–105.

Charles A. Smith and Myrtle R. Jensen, "Educational, Psychological, and Physiological Factors in Reading Readiness, I," *Elementary School Journal*, XXXVI (April, 1936), 583–94.

[17] Gates, *The Improvement of Reading*, pp. 331–71.

his visual apparatus. He has no conception of how to attack printed material, and this *novel activity of moving the eyes in a left-to-right movement, as in book reading, must be conditioned.* He should not be rushed into reading until some preparation has been made. By the use of picture rolls and word-picture rolls in the Metron-O-Scope, and vocal responses to what he sees, the child learns to recognize words, and at the same time is conditioned to use rhythmical left-to-right eye-movements. He is thus introduced to reading through experiences that are thoroughly pleasurable to him, and that compel his interest and attention. By supplementary classroom exercises during this pre-reading and initial-reading stage he becomes familiar with books and other classroom materials, and acquires specific abilities in interpreting, correlating, and expressing ideas. Thus the permanent interests which are necessary to the intelligent use of books and other printed materials in later school and adult life are developed. The importance, then, of proper training in reading at this early age cannot be overemphasized.[18]

[18] *Improvement in the Teaching of Reading.* Bureau of Research Monographs, No. 1. Baltimore, Md.: Baltimore Department of Education, Bureau of Research, 1926.

PART IV

EXPERIMENTAL STUDIES RELATING TO CONTROLLED READING

CHAPTER VII

PHYSIOLOGICAL DEFECTS AND EYE DISCOMFORT AMONG SCHOOL CHILDREN

The statement has been made frequently, in recent books and articles, that eye disorders have a direct bearing on reading efficiency. To determine the validity of this claim, and the nature of the defects that exist, an increasing number of investigators are giving attention to the study of eye deficiencies. Both the eye specialist and the teacher hope that through a well-directed preventive and corrective program the number of poor readers may be greatly reduced.

The present study was undertaken to contrast the efficiency of normal and failing students in a large school system on a series of eye and reading tests. In administering these tests a period of approximately thirty minutes was spent with each subject. The purpose of the present study was to determine (1) whether differences actually existed between the groups in terms of the tests used and (2) whether these differences were reliable.

No attempt is made to prove that any particular eye deficiency affects reading habits.

The findings within the groups, however, are contrasted in a way that indicates problems for further study.

The so-called "normal" or average group included 387 high-school pupils taken from four mathematics classes in the Austin High School (Austin, Texas), where the survey was made. The XI A subjects included in the normal group were taking an elective course in mathematics, but all the other subjects were taking the required ninth- and tenth-grade mathematics. An attempt was made to secure a cross-section of the entire student body, consisting of 2,000 pupils, by testing a few entire mathematics classes.

The group of failures consisted of 100 subjects taken at random from 152 pupils who failed to receive a passing grade in three, four, or five courses during the semester immediately preceding the one in which these data were gathered. Very few of these subjects made their first failing grades during this particular semester. The normal group was tested at the beginning of the semester, while the failures were checked after their grades for the semester had been recorded in the principal's office, so that any overlapping was purely accidental.

The Ophthalmic-Telebinocular[1] was used to se-

[1] The Telebinocular (manufactured and distributed by the Keystone View Co., Meadville, Pa.) is accurate enough for screening, as it indicates, within limits, the subjects who need a more thorough examination by an eye specialist. The Snellen chart was

cure the following information concerning visual conditions:

1. Visual acuity[2]
2. Suppression[3] or "replacement"[4]
3. Percentage of stereopsis[5]
4. Ametropia[6]
   a) Hyperopia
   b) Myopia
   c) Astigmatic errors
5. Near phoria[7]

---

not used as it is not possible to secure with it data concerning binocular co-ordination (Thomas H. Eames, "Improvement of School Eye Testing," *Education*, LVI [September, 1935], 14–17) which is essential in school survey work.

[2] Acuteness or keenness of vision.

[3] Suppression of vision is probably a compensatory reaction, conditioned by visual inefficiencies. Because of a conflict in the fusional process the image on one retina or the other is partially or completely ignored.

[4] Frederick H. Verhoeff, M.D., "A New Theory of Binocular Vision," *Archives of Ophthalmology*, XIII (February, 1935), 151–75.

[5] Depth perception.

The 23-card test was used in checking stereopsis, as almost any subject can make 100 per cent on the test with the single card which is furnished with the instrument.

[6] Out of measure—the optical apparatus does not have the correct focal length for the globe of the eye—hence any error of refraction, such as: (*a*) hyperopia, or far sight, generally resulting from a shortened eyeball, corrected by a plus or convex lens; (*b*) myopia, or near sight, generally resulting from an elongated eyeball, corrected by a minus or concave lens; (*c*) astigmatism, causing unequal focusing of the light at different points with respect to the retina. Corneal astigmatism is caused by irregularity of the curvature of the cornea; lenticular astigmatism by irregularity of the curvature of the crystalline lens. This defect is corrected by a cylindrical lens.

[7] Phoria, "a tending"—esophoria, tendency of the eyes to turn

Table II shows the distribution of the two groups with reference to average ages, grade levels, and sex.

The reading-ratio was taken with Risley rotary prisms[8] while the subjects read indicia presented in the Metron-O-Scope. For convenience, this ra-

TABLE II

Distribution of Normals and Failures according to Average Age, Grade Level, and Sex

Subjects	Average Age	Grade Level					Boys	Girls	Total
		IX A	IX B	X A	X B	XI A			
Normals...	15.83	100	32	....	147	108	178	209	387
Failures...	16.45	29	34	9	14	14	59	41	100

tio is indicated as $10^{\Delta}/26^{\Delta}$, $8^{\Delta}/30^{\Delta}$, etc. It has no significance as a ratio with reference to either one group or the other as a whole, but in testing individuals it is a very convenient method of designating the relationship between the conver-

in; exophoria, tendency of the eyes to turn out; near phoria, the degree in which the eyes turn in or out at the near point or ordinary reading distance.

[8] A rotary prism, as used in optics, is a round, wedge-shaped transparent glass with two plane surfaces. The thin edge is called the "apex" and the thick edge the "base." A ray of light passing through a prism is always deflected toward the base. The rotary prisms used in this study consisted of two prisms placed with the base of one over the apex of the other. In this position they neutralize each other, but if they are rotated the effect is a prismatic degree up to their combined values.

gence and the divergence functions while the eyes are at work. The subject is placed ten feet[9] from the instrument, and while he reads through prisms the material presented intermittently in the Metron-O-Scope, the prism power is gradually increased until the print or the instrument appears to be double ("diplopia"). In this way the functional relationship of the eye muscles is determined during the act of reading. The numerator of the ratio is the base-in reading and the denominator is the base-out reading, in terms of prism diopters. To contrast the data secured on this test, the numerators or base-in readings and the denominators or base-out readings for each group are treated separately.

The subjects were asked to report whether they experienced eye discomfort when they studied. The general tendency was not to report discomfort of a mild type. These reports were purely subjective, but they gave a fair idea of the number of subjects who experienced discomfort while doing near-point work. The subjects were asked also to estimate the average time spent daily in study after school hours. There was no way to check the accuracy of these reports, but each subject was asked to estimate the time carefully.

[9] The usual distance with the Senior Metron-O-Scope. With the Junior Metron-O-Scope (cf. pp. 147, 274), the distance is not more than two feet.

Table III contrasts the two groups with regard to (*a*) refractive conditions, (*b*) eye discomfort, and (*c*) the need of lenses. Only a few cases in each group fell below 90 per cent in visual acuity on the binocular test, although in some cases there was a decided difference in the visual acuity of the two eyes when the eyes were tested separately. In terms of visual acuity there was not enough difference between the groups to provide a contrast. In terms of the test with the Telebinocular, the groups were compared on the basis of refractive errors. This classification included: (*a*) all cases of hyperopia or myopia with an error of a quarter diopter[10] or more. In the cases indicating anisometropia,[11] the eye having the largest error determined the classification; (*b*) those having astigmatic errors that required only plus or minus cylinders for correction, as the test did not clearly differentiate between simple and compound errors. Among the normals there were more cases tending toward myopia, while among the failures there were more tending toward hyperopia. There are only a few cases with *equal* antimetropic errors (i.e., hyperme-

[10] Corrected by a lens with a focal length of 157.48 inches. A one-diopter lens has a focal length of 39.37 inches.

[11] A difference in the refraction of the two eyes. One eye may be myopic and the other hyperopic, or there may be different degrees of the same type of error in the two eyes.

TABLE III

COMPARISON OF NORMALS AND FAILURES ON BASIS OF REFRACTIVE CONDITIONS, EYE DISCOMFORT, AND NEED OF LENSES

Comparison of the Groups	Myopia	Hyperopia	Equal, + or −, or Mixed Errors	Emmetropia	Suppression
1. Percentage:					
Normals..........	51.16	41.34	1.80	5.42	8.78
Failures..........	28.00	67.00	2.00	3.00	12.00
2. Percentage of each division reporting eye discomfort:					
Normals..........	45.22	49.37	85.71	38.09	57.14
Failures..........	50.00	46.26	50.00	33.33	58.33
3. Percentage in need of lenses as indicated by the Telebinocular:					
Normals..........	15.65	35.62	......	......	......
Failures..........	17.86	38.80	......	......	......
4. Percentage of those in need of lenses reporting discomfort:					
Normals..........	52.94	55.31	......	......	......
Failures..........	60.00	53.84	......	......	......
5. Percentage of whole group needing lenses as indicated by the Telebinocular:					
Normals..........	23.51		......	......	......
Failures..........	31.00		......	......	......
6. Percentage of whole group wearing lenses:					
Normals..........	15.50		......	......	......
Failures..........	3.00		......	......	......

tropic in one eye and myopic in the other), as shown in the third column, but it is interesting to note that most of them reported eye discomfort. Column 4 shows that there were more cases of emmetropia[12] in the normal group than among the failures. A large percentage of these cases, as well as the suppression cases shown in column 5, reported eye discomfort. A check of the data showed that in the near-point test with the Telebinocular 12.40 per cent of the normal group and 26 per cent of the failures experienced difficulty in fusing the retinal images. These figures include the suppression cases.

In figuring the percentage requiring lenses only those cases which show as much as, or more than, an error of one diopter are included. This percentage is given for the two groups separately, and, as might be expected, in the failing group there are more subjects requiring lenses than in the normal group. The first and second columns show that a large percentage of the subjects in both groups experience discomfort in near-point work. Items 5 and 6 also give the percentage of the entire group needing lenses, as indicated by the Telebinocular, and the percentage wearing them. Only 3 per cent of the failures are wearing lenses, although the test shows that 31 per cent need them. The 23.51 per cent of the subjects in the normal group who need lenses, as indicated

[12] Optically correct; requiring no lens correction.

by the test, includes 68.34 per cent of those wearing them. The 23.51 per cent of normals and 31 per cent of failures in item 5 represent, in each group, the total requiring lenses. The cases that otherwise would have been shown in the third, fourth, and fifth columns are too few in number to warrant separate treatment.

Because a considerable number of the subjects in the normal group are wearing lenses, the cases experiencing discomfort were checked to see whether the wearing of lenses relieves discomfort in near-point work. Of this group 57.37 per cent report such discomfort. The test with the Telebinocular shows that in terms of visual acuity 31.66 per cent of those wearing lenses do not seem to need them. These figures indicate that there may be factors other than refractive errors which cause eye discomfort in near-point work. This conclusion is supported also by the fact that a large percentage of the so-called cases of emmetropia shown in the fourth column report discomfort. No tests were made for hyperphoria[13] or aniseikonia,[14] and if these defects are present they may affect the total efficiency of an individual and also cause discomfort.[15] A careful check of the subjects in each class included in the

[13] Vertical deviation of one eye.

[14] Difference in the size and shape of the ocular images.

[15] Walter F. Dearborn and Forrest D. Comfort, "Differences in the Size and Shape of Ocular Images as Related to Defects in

normal group shows that practically all cases which are myopic enough to require lenses are among the older students. This seems to support other observations that myopia gradually develops with continued use of the eyes in near-point work. In fact, with the exception of three cases in the IX B class, all cases of myopia in the normal group needing lenses are found in the X B and XI A classes. Even among the IX A and IX B failures it is found that only six cases of myopia need lenses, as shown by the test. All other cases of myopia with a sufficient error to need lenses are found in the older classes. The

---

Reading" (a preliminary report by the Psycho-Educational Clinic of the Harvard Graduate School of Education), *Elementary English Review*, XII (May, 1935), 131–32.

James E. Lebensohn, "Oculovisceral Reflexes—Oculogastric Reflex Experimentally Demonstrated," *American Journal of Ophthalmology*, XII (July, 1929), 562–68.

James E. Lebensohn, "Gastric Disorders of Asthenopic Origin," *Illinois Medical Journal*, LVI (August, 1929), 106–8.

A. Ames, Jr., Cordon H. Gliddon, and Kenneth N. Ogle, "Size and Type of Ocular Images, I," *Archives of Ophthalmology*, VII (April, 1932), 576–97.

Elmer H. Carleton, M.D., and Leo F. Madigan, "Size and Type of Ocular Images, II," *Archives of Ophthalmology*, VII (May, 1932), 720–38.

A. Ames, Jr., and Kenneth N. Ogle, "Size and Shape of Ocular Images, III," *Archives of Ophthalmology*, VII (June, 1932), 904–24.

Leo F. Madigan and Elmer H. Carleton, M.D., *Clinical Treatment of Aniseikonia*. Southbridge, Mass.: American Optical Co., 1934. Multigraphed.

normal group, as shown in the table, is decidedly more myopic than the failing group. This may support also the idea that excessive amounts of near-point work tend to bring on myopia.[16] It is assumed—and the reports of the time spent in study show—that on the whole the normal subjects, in their efforts to make passing marks, do spend more time than the failures in near-point work. The older students naturally have used their eyes much more than those in the IX A class, and if myopia is the result of too much near-point work, this condition, of course, would be more prevalent among the older students.

To further compare the efficiency of the two groups under consideration, the records of all the students were looked up in the principal's office to find out how many courses had been failed since the beginning of the eighth grade. The office records showed that the 387 normal subjects had failed 715 courses, and the 100 in the inferior group had failed 699 courses. A combination of these failed courses showed a total of 1,414. This equals 282.5 pupils failing five

[16] Olive Grace Henderson and Hugh G. Rowell, M.D., *Good Eyes for Life*, pp. 52–55. New York: D. Appleton–Century Co., Inc., 1933.

F. W. Marlow, M.D., "Muscle Imbalance in Myopia," *Archives of Ophthalmology*, XIII (April, 1935), 584–97.

Joseph I. Pascal, M.D., "Myopia and Exophoria," *Archives of Ophthalmology*, XIV (October, 1935), 624–26.

J. H. Berkowitz, *The Eyesight of School Children*, pp. 5–30.

courses each for one semester. In terms of the per capita cost of instruction, as furnished by the United States Bureau of Education,[17] these failures cost the school system nearly $12,000 for reteaching. Again, if we consider the groups separately, these figures indicate an average of 1.84 failed courses for each member of the normal group, and an average of 6.99 for each member of the failing group. The average number of failed courses per subject was used merely as a means of contrast, and applied only to each group as a whole, because each member had not attended the same number of terms, and consequently had not had equal chances to pass or fail the different courses.

In Table II it was observed that the failing group was somewhat older than the normal group, and this means that these subjects had had, on the average, a term longer in school than had those of the normal group.

The last test was a check of visual efficiency in reading by means of eye-movement photographs which showed the number of fixations per hundred words, the number of regressions per one hundred words, and the speed in words per minute. Each subject read a practice selection to get acquainted with the procedure, and the eye-

[17] Lula Mae Comstock, *Per Capita Costs in City Schools, 1929–1930.* U.S. Bureau of Education, Pamphlet No. 19, April, 1931. Washington: Government Printing Office.

movements were then recorded while he read new material. To indicate the degree of comprehension, each subject answered four questions based on material read. This type of test was sufficient to show that the subject had read the selection. The reading selections[18] and the questions were as follows:

Section 1:

Aladdin, no longer under fear of his father, gave himself entirely over to his idle habits, and was always on the streets. This course he followed until he was fifteen years old, without giving his mind to any useful pursuit. As he was one day playing in the streets with his vagabond associates, a stranger passing by stood and watched him closely. The stranger was an African magician, and had been but two days in the city.

Questions:

Did Aladdin spend most of his time at work?	Yes	No
Was the boy yet eighteen years old?	Yes	No
Was Aladdin watched closely by an American?	Yes	No
Did Aladdin spend most of his play time with working boys?	Yes	No

Selection 2:

The African magician, seeing that Aladdin was a boy well suited for his purpose, made inquiries about him; and after he had learned his history, called him aside and asked him about his father. Aladdin told him about his father, and in the end told him also that his father

[18] Charles H. Judd and Guy T. Buswell, *Silent Reading: A Study of the Various Types*, pp. 50–51. Supplementary Educational Monographs, No. 23. Chicago: University of Chicago, 1922.

was long since dead. At these words, the African magician threw his arms about Aladdin's neck, and kissing him with tears in his eyes, said, "I am your uncle."

Questions:

Was the African who watched Aladdin a musician?	Yes	No
Had the African previously known Aladdin?	Yes	No
Did Aladdin tell the African that his father was dead?	Yes	No
Did the African say that he was Aladdin's uncle?	Yes	No

These selections were taken from the same story and, therefore, it was assumed that they were of about the same degree of difficulty. To make sure that any difference between them would not affect the final results, approximately half of each group read the first and the other half the second selection. This arrangement also took care of any accidents in photography. To secure usable reading-graphs it was necessary to rephotograph about twenty subjects. In making the second record these subjects were required to read the selection they had not read in the first photography so that the practice gained in reading the original selection would not affect the final results of the test.

Table IV gives the percentage of stereopsis; the reading efficiency in terms of fixations, regressions, speed, and comprehension; the average number of minutes spent in study each day after school hours; the reading-ratio; and the near

TABLE IV

DATA ON NORMALS AND FAILURES—MEANS, STANDARD DEVIATIONS, AND RELIABILITIES OF DIFFERENCES

Nature of Data	Mean	σ	Standard Error of the Mean	Difference of the Means: Failures minus Normals	σ of the Difference	Ratio of the Difference to σ of the Difference	Reliabilities of the Differences
1. Number of fixations per 100 words	.....	.....	.....	8.45	2.29	3.69	99
Normals	92.39	19.70	1.00	....	....	....	....
Failures	100.84	20.74	2.06	....	....	....	....
2. Number of regressions per 100 words	.....	.....	.....	1.96	1.11	1.77	96
Normals	18.00	9.49	0.48	....	....	....	....
Failures	19.96	10.10	1.00	....	....	....	....
3. Comprehension	.....	.....	.....	10.00	2.715	3.683	99
Normals	82.77	20.70	1.05	....	....	....	....
Failures	72.77	25.15	2.50	....	....	....	....
4. Speed in words per minute	.....	.....	.....	5.84	9.40	.62	73
Normals	294.84	76.43	5.84	....	....	....	....
Failures	289.00	85.50	8.55	....	....	....	....
5. Minutes spent in study	.....	.....	.....	9.10	4.89	1.86	97
Normals	64.90	47.73	2.43	....	....	....	....
Failures	55.80	42.60	4.24	....	....	....	....
6. Near phoria	.....	.....	.....	.01	.014	.714	76
Normals	4.17	1.25	.09	....	....	....	....
Failures	4.18	1.34	.10	....	....	....	....
7. Stereopsis	.....	.....	.....	4.05	3.19	1.27	90
Normals	42.25	25.28	1.29	....	....	....	....
Failures	46.30	29.35	2.92	....	....	....	....

TABLE IV—*Continued*

Nature of Data	Mean	σ	Standard Error of the Mean	Difference of the Means: Failures minus Normals	σ of the Difference	Ratio of the Difference to σ of the Difference	Reliabilities of the Differences
8. Reading-ratio:							
Numerators, or base-in reading	.....	.....	.....	.18	.23	.80	79
Normals.	10.17	2.10	.11	.....	.....	.....	.....
Failures..	9.99	1.97	.20	.....	.....	.....	.....
Denominators, or base-out reading	.....	.....	.....	1.58	.93	1.70	96
Normals.	26.17	7.54	.39	.....	.....	.....	.....
Failures..	24.59	8.29	.84	.....	.....	.....	.....

phoria. These data are given some statistical treatment to determine the reliabilities of the differences between the groups. It is interesting to note that all the standard deviations for the normal group, except for the minutes spent in study and the base-in readings, are smaller than the corresponding deviations for the failing group. This would seem to indicate that, with reference to the elements tested, there is a higher degree of variation within the failing group than within the normal group. The differences between the two groups in terms of the factors studied are not pronounced, but they are highly reliable in most instances. In fact, all the

differences except speed in words per minute, near phoria, and the base-in readings are highly reliable. This higher reliability of the differences found for the base-out readings is especially interesting, since it is believed that the desire for fusion can increase the amplitude of convergence.[19] The eye-muscle test is made while the subjects are actually engaged in reading, on the assumption that while in the act of reading the subject will put forth a little more effort to maintain fusion than when a static test is employed to check muscular conditions. The difference in the base-out readings is also significant in that a great deal of eye discomfort is probably due to neuro-muscular deficiencies.[20] This discomfort is particularly associated with convergence insufficiencies. Some writers[21] state also that binocular

[19] Alfred Bielschowsky, "Lectures on Motor Anomalies of the Eyes, III: Paralyses of the Conjugate Movements of the Eyes," *Archives of Ophthalmology*, XIII (April, 1935), 569–83.

Duke-Elder, *Text Book of Ophthalmology*, I, 608.

Convergence—turning the eyes from their habitual position of rest. Amplitude of convergence—the total amount of convergence for the individual.

[20] Conrad Berens, M.D., Ray R. Losey, M.D., and LeGrand H. Hardy, M.D., "Routine Examinations of the Ocular Muscles and Non-operative Treatment," *American Journal of Ophthalmology*, X (December, 1927), 910–18.

[21] Charles A. Selzer, *Lateral Dominance and Visual Fusion.* Harvard Monograph in Education, No. 12. Cambridge, Mass.: Harvard University, 1933.

Walter F. Dearborn, "Structural Factors Which Condition Special Disability in Reading," *Proceedings and Addresses of the*

imbalances are directly associated with poor reading, and this makes the high reliability of the differences in convergence ability between the groups more significant.

It is sometimes suggested that stereopsis is a factor in reading disability. The 23-card test for stereopsis shows that the failures have more stereopsis than the normals; and a check of this difference shows that it is fairly reliable. In terms of the items studied by means of the eye-movement photographs, however, they are inferior to the normals, which would seem to indicate that depth perception is not directly related to reading ability.

Some other findings in connection with the data in Table IV may be of interest. In the normal X B class, 57.13 per cent report that they experience discomfort in near-point work. Perhaps the most interesting fact brought out with these data is that this class failed 337 of the 715 failed courses. It is true that it is the largest class, but not much larger than the XI A normal class, which has had one more term in which

---

Fifty-seventh Annual Session of the American Association on Mental Deficiency, XXXVIII (1933), 8.

Brant Clark, "The Effects of Binocular Imbalance in the Behavior of the Eyes during Reading," *Journal of Educational Psychology*, XXVI (October, 1935), 530–38.

Thomas H. Eames, "Frequency Study of Physical Handicaps in Reading Disability and Unselected Groups," *Journal of Educational Research*, XXIX (September, 1935), 1–5.

to fail courses. In proportion to the number of members, the XI A class reports fewer cases of discomfort and also fewer failed courses than the other classes.

Table IV indicates that the differences between the groups are small but in most instances highly reliable. Table II shows that there is some difference in the average age of the two groups. Theoretically, pupils of the same age should be about equally advanced in school and in maturity, and it may be argued that this difference in age and experience in favor of the failing group will tend to decrease the differences between the groups in terms of the tests used. In Table V all the IX A's are eliminated, therefore, from the normal group, so that the comparisons are between pupils of about the same age level. After the elimination of the IX A's, the average age of the normal group is 16.22 years. The average age of the failing group is still slightly higher—16.43 years—than that of the normal group, but the differences between the groups are changed.

Table V shows also that, after eliminating the IX A's from the normal group, the standard deviations of the normal group are still smaller than those of the failing group, except for minutes spent in study and base-in readings; and the differences between the groups are all higher and more reliable, except the near phoria and base-in and base-out readings. There is a greater differ-

TABLE V

Data on Normals and Failures—Reliabilities of Differences after Eliminating IX A Class To Balance Ages

Nature of Data	Mean	σ	Standard Error of the Mean	Difference of the Means: Failures minus Normals	σ of the Difference	Ratio of the Difference to the σ of the Difference	Reliabilities of the Differences
1. Number of fixations per 100 words				10.65	2.37	4.49	99
Normals	90.19	19.73	1.17				
Failures	100.84	20.74	2.06				
2. Number of regressions per 100 words				2.56	1.14	2.25	99
Normals	17.40	9.54	.56				
Failures	19.96	10.10	1.00				
3. Comprehension				13.77	2.84	4.85	99
Normals	86.54	22.67	1.34				
Failures	72.77	25.15	2.50				
4. Speed in words per minute				17.27	9.74	1.77	96
Normals	306.27	78.60	4.66				
Failures	289.00	85.50	8.55				
5. Minutes spent in study				9.17	5.08	1.81	96
Normals	64.97	47.27	2.79				
Failures	55.80	42.60	4.24				
6. Near phoria				.035	.125	.28	61
Normals	4.135	1.27	.08				
Failures	4.18	1.34	.10				
7. Stereopsis				4.31	3.30	1.31	90
Normals	41.99	25.94	1.53				
Failures	46.30	29.35	2.92				

TABLE V—*Continued*

Nature of Data	Mean	σ	Standard Error of the Mean	Difference of the Means: Failures minus Normals	σ of the Difference	Ratio of the Difference to the σ of the Difference	Reliability of the Differences
8. Reading-ratio:							
Numerator or base-in reading							
Normals	9.99	2.00	.12				
Failures	9.99	1.97	.20				
Denominator or base-out reading				.82	.58	1.41	92
Normals	25.41	7.19	.43				
Failures	24.59	8.29	.84				

ence between the groups in the percentage of stereopsis present, but the reliability of the difference does not increase. It is interesting to note that in this new arrangement there is no difference between the base-in readings of the two groups; and the difference in the base-out readings is still highly reliable.

The tables and the discussion show that there are differences between the failing and the normal groups, and that in most instances these differences are highly reliable. It has been assumed for some time that differences exist between good and poor students in terms of fixations, regressions, speed, and comprehension in reading, but

these factors have not been studied by means of eye-movement photography in so large a group as the one under consideration. It is true that the differences between the groups, so far as these items are concerned, are not large; but with the exception of difference in speed—as shown in Table IV—they are highly reliable. Table V shows that, when the age level of the normal group is changed, these differences between the two groups are greater, and in every case they are highly reliable.

No test is strenuous enough or long enough to bring in the fatigue factor, and this will have to be considered in showing that eye anomalies are related to reading inefficiency. The subject can compensate for certain eye defects for a short period of time, and they apparently do not affect his performance, but if reading is continued to the point of fatigue it is reasonable to expect these defects to influence reading ability.

In terms of the tests used there seems to be little relationship between *visual acuity*, as an isolated factor, and reading efficiency. There is not much difference between the groups in *near phoria*, and this difference is not very reliable; therefore, near phoria probably cannot be considered an important factor in diagnosing reading disability. In Table V the differences shown for near phoria are even less reliable than those in Table IV. It is fairly obvious that *stereopsis* also is not directly associated with reading efficiency.

The most significant findings in this study are those connected with eye discomfort as influenced by *refractive errors*, *suppression*, and *convergence insufficiency*. It cannot be shown that any of these particular defects directly influence reading efficiency because of the compensatory ability of the individual organism, but some of the factors considered do suggest a relationship. Doubtless pronounced errors of refraction—hyperopia, myopia, and astigmatic errors—do influence general reading efficiency, but in the group studied there are not enough cases of this type to justify any conclusion. There are more cases of hyperopia among the failures than among the normal subjects. Unless a subject has the ability to compensate by excessive accommodation, hyperopia results in a blurred retinal image at the near point. This would naturally result in inaccurate perception and inefficient reading. The fact that the normal subjects are more myopic than the failing subjects indicates that myopia alone, especially in low degrees, does not influence reading efficiency at the near point. The high percentage of myopia in the older classes, however, suggests that the continued use of the eyes in near-point work tends to accelerate the development of this defect. There are more cases of suppression in the failing than in the normal group, and it seems reasonable to suppose that this defect may influence general reading efficiency. It is a well-known fact that eye dis-

comfort associated with disturbances of either negative or positive convergence affects the general efficiency of the individual.

The findings in this study and in chapter xii indicate the importance of considering eye discomfort and its causes in every comprehensive reading program.

CHAPTER VIII

VISUAL INEFFICIENCIES AS RELATED TO FAILURE IN MATHEMATICS

At the college level, as well as in secondary-school, more students fail in mathematics than in any other subject. The elementary-school teacher has been blamed first, then the high-school teacher, and then the college teacher. Those teaching at the various levels of instruction have at times placed the blame on teachers at other levels, if they have not held the student responsible. The lack of understanding the idea of number, as well as the terminology of mathematics, is doubtless a primary cause of failure.[1] Additional factors in school failure are lack of preparation on the part of the teacher, inability to teach, and inadequacy of classroom facilities, but these alone cannot be held responsible for the fact that the percentage of failures in mathematics is higher than in any other subject. In ex-

[1] Guy T. Buswell and Lenore John, *The Vocabulary of Arithmetic*. Supplementary Educational Monographs, No. 38. Chicago: University of Chicago, 1931.

Guy T. Buswell and Charles H. Judd, *Summary of Educational Investigations Relating to Arithmetic*. Supplementary Educational Monographs, No. 27. Chicago: University of Chicago, 1925.

planation of the condition it has been stated that only a certain percentage of the population has the mental capacity for this subject. This argument cannot be sustained, because the conditions found on the lower levels of instruction prevail in college also, and the mentally retarded usually are eliminated from the school population before they reach the college level. Table VI gives the

TABLE VI

PERCENTAGES OF FAILURE IN FOUR BASIC SUBJECTS AMONG COLLEGE FRESHMEN IN TEXAS*

Year	History	English	Science	Mathematics
1925–26	13.5	16.3	18.8	24.6
1927–28	15.1	14.2	21.2	30.1
1928–29	14.2	13.9	21.4	25.3
1929–30	11.6	13.1	14.7	24.8
Average	13.6	14.4	19.0	26.2

* Charles R. Sherer, "Does the Present High School Curriculum in Mathematics Prepare Students for College," *Texas Mathematics Teachers Bulletin*, XVIII (February 8, 1934), 44.

percentages of failures among college Freshmen in Texas, in the four basic subjects, for the years indicated in the table. According to these data a greater number of students failed in mathematics than in any other subject.

Failure in mathematics has also been attributed to the psychological effect of remarks made by older persons about the difficulty of the subject, which would tend to discourage consistent effort on the part of the student. It has sometimes been

attributed to the dislike of the average student for the subject, and some college teachers believe that failure in their mathematics classes is due to lack of preparation at lower levels of instruction. The validity of some of these claims was checked by data gathered from 821 pupils in the IX A, X A, and XI A classes in a large high school.[2] The students were asked to list the subjects which they were then studying, and to indicate the ones that they liked the best and the ones that they liked the least. Of the total number of students, 707 were taking mathematics, 571 history, 794 English, and 406 science. Table VII gives the percentages of failures in each of these subjects during that school year. The data also indicate that, as far as these students are concerned, mathematics is more interesting, or is better liked, than either English or history. In this instance, at least, it cannot be said that personal feeling in regard to the subject influenced the success or failure of the students.

Comparison of the data in Tables VI and VII indicates that although more high-school students failed in English than in science, and more college Freshmen failed in science than in English, as far as mathematics is concerned the percentage of failures is about the same in the two groups. This seems to indicate that the causes underlying failure exist before the students reach

[2] In Austin, Tex.

high school. As a similar condition exists in the junior high school, the fundamental difficulty seems to have developed in the elementary school and yet it is not the fault of the elementary-school teacher.

A number of investigators[3] have found that reading material containing mathematical symbols and formulas requires more fixations per line of print and more careful eye-movements than any other type of reading. It is sometimes said that English and history require more reading

TABLE VII

PREFERENCE AND SUCCESS IN FOUR BASIC SUBJECTS IN HIGH SCHOOL

Basic Subjects	History	English	Science	Mathematics
Percentage liking subject.	18.2	13.8	30.4	20.08
Percentage disliking subject.	26.6	24.05	23.6	26.1
Percentage failing for whole school (about 1,800 pupils)	11.0	16.8	14.6	23.0

[3] P. W. Terry, *How Numerals Are Read.* Supplementary Educational Monographs, No. 18. Chicago: University of Chicago, 1922.

Miles A.. Tinker, "Numerals versus Words for Efficiency in Reading," *Journal of Applied Psychology,* XII (March, 1928), 190–99.

Dearborn, *The Psychology of Reading*, pp. 67–73.

Tinker, *A Photographic Study of Eye-Movements in Reading Formulae*, pp. 95–182.

than mathematics. More words to be covered, perhaps, but not with the hundreds of minute fixations and regressions made by an inefficient reader in a careful study of mathematical formulas or word problems. The student whose eyes are not well co-ordinated and who lacks mechanical skill in reading is, therefore, at a decided disadvantage in a study of mathematics. Just as the athlete's muscles are trained for co-ordination, so the student's eye muscles should be trained for precision of movement and accuracy of focus. Mills says: "Much eye disturbance, especially in the hyperopia of youth, results from a lack of sufficient interest to arouse one to the pitch of seeing sharply."[4] Many students, therefore, probably never learn to see sharply, or to bring their eyes to a proper focus. Consequently they have to look at the same print a number of times, or for a longer period than is normally required, to get the meaning.

There is probably a further explanation of the lack of functional efficiency on the part of the pupil. Traditional methods of teaching have not provided specific training designed to increase the total *functional efficiency* of the *visual apparatus* during the act of reading. The reader may

[4] Lloyd Mills, M.D., "The Functions of the Eyes in the Acquisition of an Education," *Journal of American Medical Association*, XCIII (September 14, 1929), 841–45.

experience difficulty in maintaining accommodation and convergence at the same time that he controls the lateral movements of the eyes. Under these circumstances the student is not going to be very conscientious about studying for long periods of time. If he cannot acquire his information rapidly, he does not get it at all, and this is reflected immediately in his school grades. Any type of fusional conflict resulting from muscular innervational deficiencies, refractive errors, or accommodative and convergence fatigue is a serious handicap to the student carrying a normal school load. Unless he is able to make suitable compensatory reactions for the defect, he soon falls behind, loses interest, and is classed with the failures. The student may not be aware of any existing visual inefficiencies, because, unless the condition is the result of an accident, he has probably never known normal vision. His ability to compensate may enable him to make some progress in school, and the teacher may not be aware of the disturbing influences which contribute to his low grades.

An examination of the following data will show that there is a foundation for the belief that visual inefficiency influences the success of the student of mathematics. These data were gathered from repeaters in the mathematics

classes in the Austin High School summer session. Each of the fifty subjects (twenty-five boys and twenty-five girls) had repeated one or more courses from one to four times. Their eye-movements were photographed while they read two selections from the camera cards.[5] They were given the Otis Self-administering Test of Mental Ability, vision was checked by means of the Snellen chart, and reading-ratios were obtained with Risley double rotary prisms while the subjects read indicia from the Metron-O-Scope. The data indicated that seven boys and twelve girls needed lenses, although only three were wearing them. The reading-ratios indicated that the majority of the subjects had muscular deficiencies in a sufficient degree to be a factor in general reading efficiency. In almost all these cases it is probable that prism-reading exercises or lenses, or both, would have produced comfortable vision, and in a few instances doubtless the need for lenses would have been eliminated by these exercises. Many of the subjects suffered from headaches, probably due in some instances to binocular imbalances and refractive errors. In the cases where the parents co-operated to pro-

[5] The fact that two different types of portable eye-movement cameras were used explains the presence of both monocular and binocular graphs.

vide prism-reading exercises this training proved to be beneficial.

Figures 26 and 27 are the reading-graphs of one of the cases where prism-reading exercises were given. This girl had severe headaches and during the school year 1932–33 missed an average of one day a week. She was fitted with lenses, but this did not relieve the eye discomfort. At the beginning of the school year 1933–34 she was given prism-reading exercises, and as a result secured comfortable vision. During that school year she did not miss a day on account of headaches, and her school grades showed an improvement. It is obvious from the reading-graph that her reading also improved.

Before training she made 154 fixations and 19 regressions while reading at a speed of 202.97 words per minute, with a comprehension score of 66.66. After training, while reading a similar selection of 148 words, she made 113 fixations and 11 regressions while reading at a speed of 308.86 words per minute, with a comprehension score of 83.33. If she had received special training in reading, or corrective measures had been adopted earlier, in all probability the eye discomfort would not have developed. This is typical of the cases among failures in mathematics where lack of efficient eye habits, together with the increasing amount of near-point work in the high school, combines to produce eye discomfort

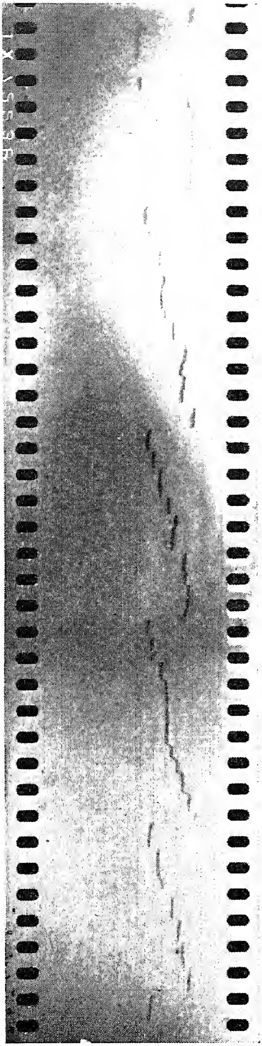


FIG. 26

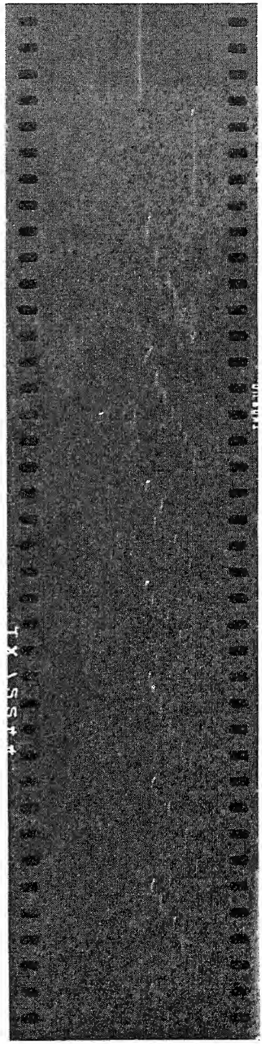


FIG. 27

MONOCULAR READING-GRAPHS OF HIGH-SCHOOL GIRL BEFORE AND AFTER PRISM-READING

which affects the general efficiency of the individual.

Table VIII contrasts the group of repeaters in mathematics with a group of fifty normal or average students from the same high school, distributed over the whole range of grades. In this normal group there are a few failures, as well as some of the best students in the school.

All the subjects were given the Otis Test and read from the camera cards the same selections that had been used in the preliminary photography of the failures. Vision was checked with the Snellen chart, and the reading-ratio of each subject was obtained. The data from the tests and the reading-graphs of all the subjects in the two groups are shown in Table VIII. The reading material contained 148 words.

In every item studied the normals surpassed the failures. In comprehension, however, it was found that the failures were almost as effective as the normals in reading the non-technical selections on the camera cards. These data would seem to indicate that a great deal of the difficulty experienced by the failures in mathematics can be traced to the lack of mechanical skill in reading. They are probably not able to see and comprehend material containing mathematical symbols and formulas and a difficult terminology as rapidly as the normals, because of fusional conflicts. The reading-graphs of the failures are

TABLE VIII

COMPARISON OF FIFTY MATHEMATICS FAILURES AND FIFTY NORMAL STUDENTS*

Item	Means: Normal	Means: Failure	Ratio Diff. of M./P.E.	Reliabilities of Differences
I.Q.	106.6 ± 1.17 12.39	91.96 ± 7.21 7.56	10.68	100
	Difference 14.64 ± 1.37			
Fixations 148 words	120 ± 1.86 19.60	143.20 ± 2.12 22.27	8.22	100
	Difference 23.20 ± 2.82			
Regressions 148 words	15.08 ± .64 6.76	23.12 ± .98 10.29	6.87	100
	Difference 8.04 ± 1.17			
Time for reading 148 words	33.12 ± .736 7.72	39.80 ± .246 2.59	6.24	100
	Difference 6.68 ± 1.07			
Comprehension for 148 words	84.76 ± .99 10.4	82.68 ± 1.06 11.18	1.4	61
	Difference 2.08 ± 1.45			

* Reading data for each group based on the same selection of 148 words.

characterized by (*a*) longer fixations, (*b*) an excessive number of fixations, and (*c*) an excessive number of regressive or corrective eye movements. The duration of the fixations indicates that these subjects require a longer reaction time[6] than the normals do in reading this type of material. These irregularities suggest deficiencies of perception and lack of motor control of the eyes as causative factors.

The standard deviation for the time spent in reading is only 2.59 for the mathematics failures, while it is 7.72 for the normals, indicating that the failures were all uniformly slower than the normals. A student with the inefficient eye habit which characterized the failures would have little chance of keeping pace with efficient readers in a mathematics class.

The reliabilities of the differences in Table VIII are also of interest. If the ratio of the differences of the means and the probable error of the differences is greater than four, the differences are very reliable. In all items except comprehension the critical ratio is very high. This indicates that the differences between the two groups are highly reliable.

[6] Miles A. Tinker, "Reading Reactions for Mathematical Formulae," *Journal of Experimental Psychology*, IX (December, 1926), 444–67.

Gordon Nevin Rebert, "A Laboratory Study of the Reading of Formulas and Familiar Numerals," Doctor's dissertation, University of Chicago, 1929.

The I.Q. rating of the normals is higher than that of the failures, yet comprehension, as tested from the material on the camera cards, is about the same for the two groups. This again emphasizes the time element. The time required for comprehension was probably longer in the case of the failures because of lack of co-ordination between the mechanical and interpretative processes in reading. Teachers frequently find that students who rank as A's in a class where the time element is not important drop to B or C rank when the time element is introduced. Table VIII would seem to indicate that difficulties which become apparent in situations involving the time element are due, in part at least, to visual inefficiencies which retard the reading process.

In order to bring out some of the differences between the two groups four reading-graphs are introduced. Figures 28 and 29 are typical of the graphs in the group of failures. These two subjects experienced much difficulty in mathematics. The irregularity of the eye-movements is very noticeable. It appears that almost every letter was observed as the subjects attempted to read. The tests indicate that both of them had refractive errors and binocular imbalances which were probably great enough to cause reading deficiencies. Figures 30 and 31 represent efficient readers in the normal group. They provide a decided contrast, showing little evidence of difficulty in

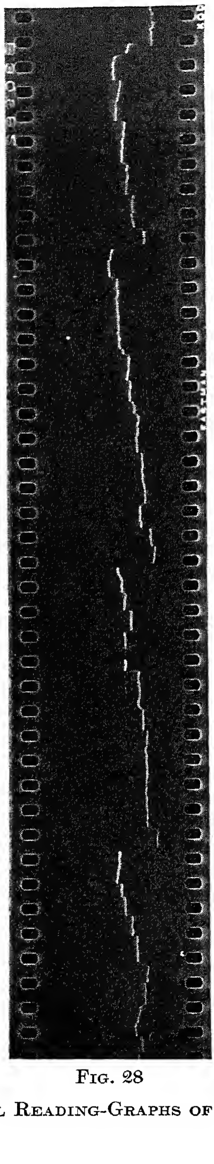


FIG. 28

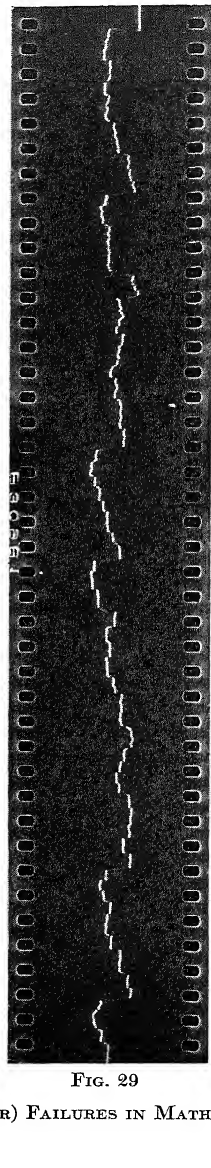


FIG. 29

TYPICAL READING-GRAPHS OF (MONOCULAR) FAILURES IN MATHEMATICS

PLATE LXIX

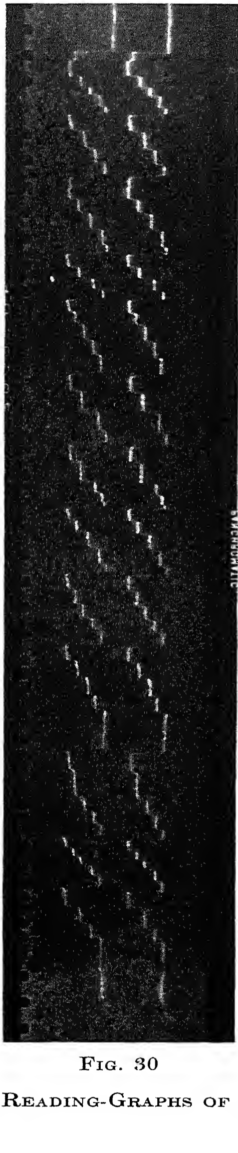


FIG. 30

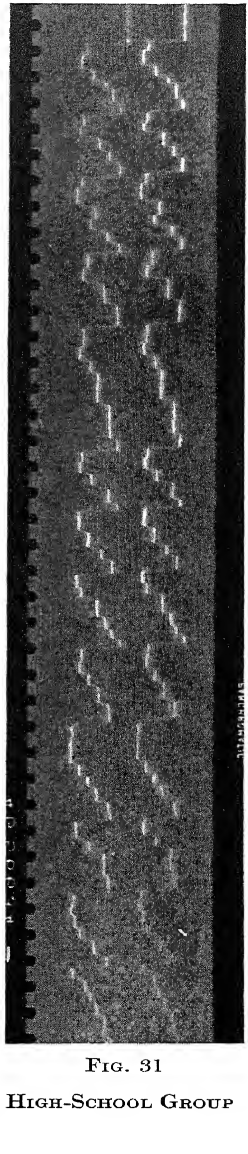


FIG. 31

READING-GRAPHS OF SUBJECTS IN THE HIGH-SCHOOL GROUP

PLATE LXX

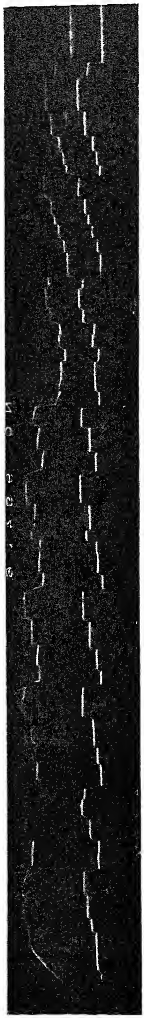


Fig. 32

Reading-Graph of High-School Girl Showing Reaction to a Fusional Conflict

reading the non-technical selections used in the photography.

Figure 32, the reading-graph of a high-school girl, indicates the importance of a *binocular* eye-movement photograph. This graph shows that, after a short period of reading, all attempts at fusion are abandoned. This girl experiences considerable difficulty in mathematics, but manages to make passing marks in her courses. It is obvious, however, that any study on her part must involve the expenditure of an enormous amount of neural energy. After reading two lines, as shown in the graph, the right eye overconverges, perhaps because there is a fusional conflict. This condition can be corrected, but until remedial measures are adopted she will neither have comfortable vision nor be an efficient reader.

To be sure, all the difficulties experienced by those who fail in mathematics do not result from visual inefficiencies, which may influence the fusional process and the mechanical skill in reading. The findings in this study, however, lead to the conclusion that controlled reading training for children in the primary grades and the application of corrective measures at higher levels of instruction will eliminate many of the difficulties experienced in the learning and in the teaching of mathematics, as well as other school subjects.

CHAPTER IX

A PRELIMINARY STUDY OF METRON-O-SCOPIC READING[1]

The purpose of this study was to determine by means of photographic records of eye-movements (*a*) how the eyes actually behave when reading from the Metron-O-Scope, (*b*) whether four students who were given remedial reading exercises on the Metron-O-Scope improved during the training, and (*c*) whether the new reading habits so formed had any permanency.

The first step in the experiment was the photography of the eye-movements of each subject to obtain a record of the fixations, regressions, speed of reading, and degree of comprehension. Each subject read three selections from the camera cards, which was essentially the same as reading from a book.[2] One card contained a practice selection, to acquaint the subject with the ex-

[1] The data were gathered in the laboratory of educational psychology at the University of Texas. Dr. B. F. Holland secured the subjects from his classes in educational psychology, and photographed the eye movements before and after training, using the large camera shown on pp. 70, 71.

The Metron-O-Scope shown on p. 144 was used in this study.

[2] The reading material on the camera cards used in this experiment was from the story of Aladdin.

perimental situation; and the other two selections were read while the eye-movements were being photographed. In each instance the subject was instructed to read as rapidly as possible but with sufficient comprehension to answer questions on the material read.

The practice periods were held on Tuesday and Thursday afternoons for a period of two months. Two boys and two girls, all college Sophomores, participated in the experiment, though they did not all attend every practice period. One subject was present only four times. About thirty minutes were necessary for each practice period, but the time spent actually reading was approximately twenty minutes. At the first practice period each subject read three selections: (*a*) a series of *X*'s printed in the three windows of the Metron-O-Scope, so that the eyes would tend to become accustomed to rhythmical left-to-right movement, (*b*) a roll of heterogeneous words, and (*c*) a roll of simple reading material, selected from "A Manual of Reading Exercises for Freshmen."[4]

At each subsequent practice period the subjects read from (*a*) a roll of heterogeneous words, (*b*) the roll used as the final selection at the preceding practice period, and (*c*) a roll containing new material from the Manual.

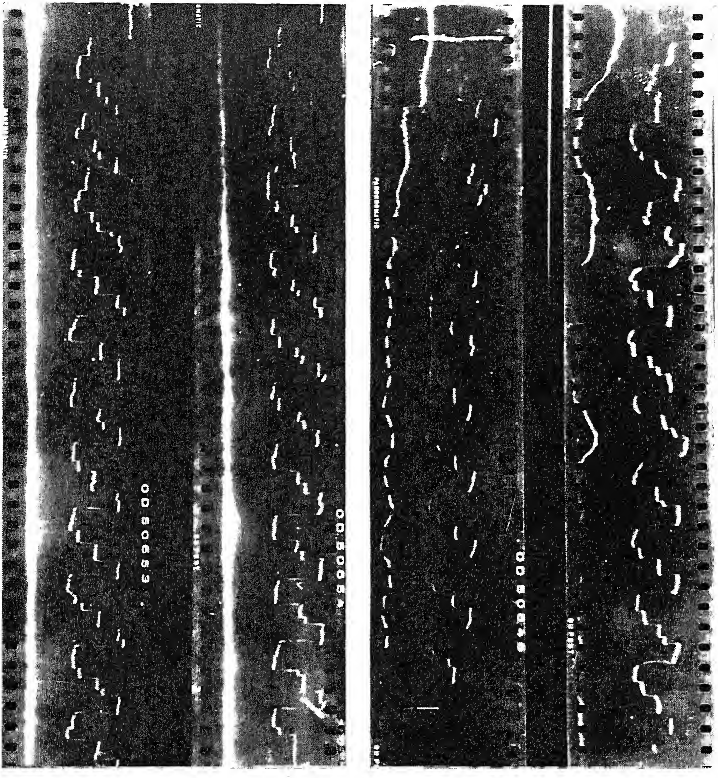
[3] The Metron-O-Scope shown on p. 144.

[4] With permission of the author, Luella Pressey Cole.

Reading-graphs of the four subjects, taken at the end of the training period while they read material from the Metron-O-Scope,[5] are shown on Plates LXXI and LXXII. Figures 33, 35, 37, and 39 are graphs made while the subjects read a practice selection, and Figures 34, 36, 38, and 40 are graphs made after the instrument has been adjusted and the subjects were acquainted with the experimental situation. The Metron-O-Scope presented the material at approximately 420 words per minute. In some of the photographs two fixations are shown for each opening of the shutter. This is especially noticeable in the case of C.B. (Figs. 33–34). He probably tried to read too rapidly and had to wait for each shutter to open, and then found it necessary to refixate to get the material presented, or the machine was running slowly enough to enable him to make two fixations at each opening. The few fixations shown in the other graphs substantiate the belief that in reading from the Metron-O-Scope subjects practice efficient reading habits. With this mechanical system of control the reader's eyes become accustomed to rhythmic left-to-right movement—a habit which carries over to book reading. In reading the practice selection the

[5] The small Metron-O-Scope shown on p. 145. Additional material from the story of Aladdin was typewritten on the rolls used in it.

PLATE LXXI



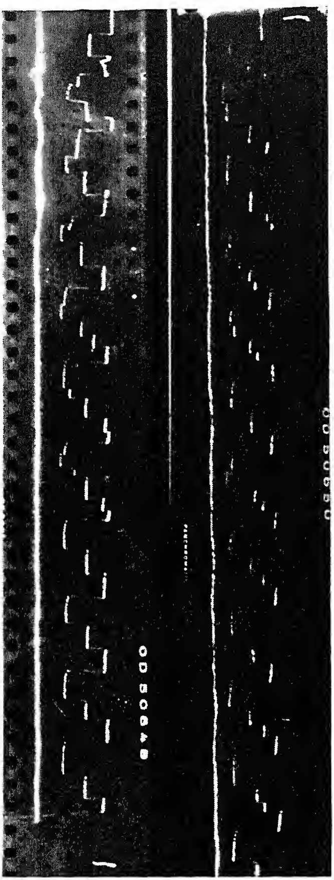
C. B. V. R.

Fig. 33 Fig. 34 Fig. 35 Fig. 36

Monocular Reading-Graphs of Two College Sophomores at End of Two-Month Period of Training in Controlled Reading

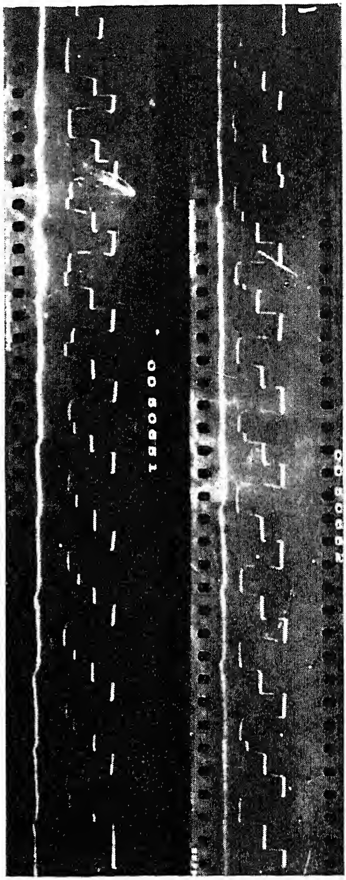
Taken while the subjects read from the small Metron-O-Scope (cf. p. 145)

PLATE LXXII



H. S.

FIG. 37 FIG. 38



S. H.

FIG. 39 FIG. 40

MONOCULAR READING-GRAPHS OF TWO COLLEGE SOPHOMORES AT END OF TWO-MONTH PERIOD OF TRAINING IN CONTROLLED READING

Taken while the subjects read from the small Metron-O-Scope (cf. p. 145)

comprehension score[6] is low in all cases but on the second reading, shown in the graph at the right in each figure, the comprehension score in every instance is 100 per cent. It is interesting to note that in reading at this rate from the Metron-O-Scope the subjects all make better scores in comprehension than they do while reading at a slower speed from the camera cards, which is comparable to reading from a book.

Table IX, which is based on one hundred words of reading material, gives the standing of each subject on each of the items studied. The data indicate that the number of fixations and regressions decreased during the training. For instance, C. B., who attended nine practice periods, shows a decrease of 24.01 per cent in the number of fixations and 81.29 per cent in the number of regressions. S. H., who had only four practice periods, even shows improvement in terms of these items. H. S. made fewer fixations and regressions before training than did any of the other subjects, and with six practice periods shows more improvement than either V. S. or S. H. With reference to speed, all the subjects show an improvement, which would be expected with the decrease in the number of fixations and regressions.

[6] Comprehension in this instance was checked by means of four written questions, answered by checking "yes" or "no," similar to those used in connection with the camera cards.

TABLE IX

Comparison of Reading Data on Four Subjects before and after Training with the Metron-O-Scope

	C. B.	V. R.	H. S.	S. H.
Fixations:				
Before	82.78	70.73	69.91	94.30
After	62.90	65.21	59.13	83.47
Percentage of decrease	24.01	7.90	15.42	11.48
Regressions:				
Before	17.21	10.56	5.69	17.80
After	3.22	5.20	3.47	11.30
Percentage of decrease	81.29	50.76	39.02	36.52
Time in seconds:				
Before	21.04	15.77	19.47	26.76
After	12.87	15.65	13.79	26.43
Percentage of decrease	38.83	.76	29.17	1.23
Comprehension on three selections:				
Before	91.66	91.66	83.33	75.00
After	83.33	83.33	100.00	91.66
Number of practice periods attended	9	8	6	4
Average rate of words per minute:				
Before	285.17	380.46	308.17	224.21
After	466.20	383.39	435.10	227.01
Percentage of increase	63.48	.77	41.18	1.25
Average span of recognition:				
Before	1.20	1.41	1.43	1.06
After	1.58	1.53	1.68	1.19

The data support the hypothesis on which the Metron-O-Scope was built, namely, that by means of controlled reading a subject can be conditioned to read with fewer fixations and regressions than he habitually makes. The apparent increase in the average number of words per fixation seems to indicate also that the training conditions an increase in the span of recognition. It is noticed that all the subjects acquired, at least to some extent, better reading habits, although individual variability determines the amount of training required to bring about improvement in each case.

The four subjects were photographed six months after the end of the training period to check the permanency of the habits formed. Table X compares the data secured before training with that secured six months after the end of the training period. The improvement shown by three of the subjects seems to be relatively permanent, while V. R. apparently lost in all items except the number of regressions. It is observed that H. S. made fewer fixations and regressions six months later than he did at the end of the training period. C. B., H. S., and S. H., even after the lapse of six months, were reading more rapidly than they did before training, which also speaks for the permanency of the results obtained. The fact that these subjects also could see more words per fixation than before training seems to indicate that the increased span

TABLE X

COMPARISON OF READING DATA ON FOUR SUBJECTS BEFORE TRAINING WITH THE METRON-O-SCOPE AND SIX MONTHS AFTER END OF TRAINING PERIOD

Nature of Data	C. B.	V. R.	H. S.	S. H.
Fixations:				
Before	82.78	70.73	69.91	94.30
After six months	71.51	73.25	56.40	88.31
Percentage of decrease	13.61	Increase of 3.56	19.32	6.35
Regressions:				
Before	17.21	10.56	5.69	17.80
After six months	4.07	8.14	2.89	13.95
Percentage of decrease	76.35	22.92	49.21	21.63
Time in seconds:				
Before	21.04	15.77	19.47	26.76
After six months	16.13	18.67	15.69	24.05
Percentage of decrease	23.34	Increase of 18.39	19.41	10.13
Comprehension:				
Before	91.66	91.66	83.33	75.00
After six months	75.00	58.33	75.00	58.33
Number of practice periods attended	9	8	6	4
Average rate of words per minute:				
Before	285.17	380.46	308.17	224.21
After six months	371.97	321.37	382.40	249.48
Percentage of increase	30.44	Decrease 15.53	24.09	11.27
Average span of recognition:				
Before	1.20	1.41	1.43	1.06
After six months	1.39	1.39	1.79	1.14

PLATE LXXIII

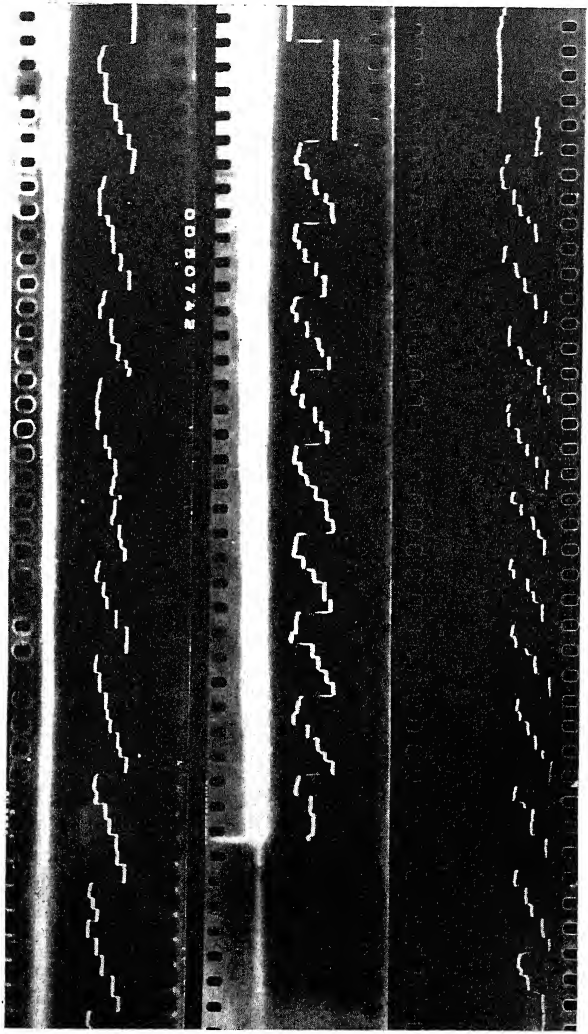


FIG. 41 FIG. 42 FIG. 43

MONOCULAR READING-GRAPHS OF C. B., A COLLEGE SOPHOMORE

FIG. 41.—Before training in controlled reading. FIG. 42.—After six thirty-minute practice periods. FIG. 43.—Six months after the training was completed.

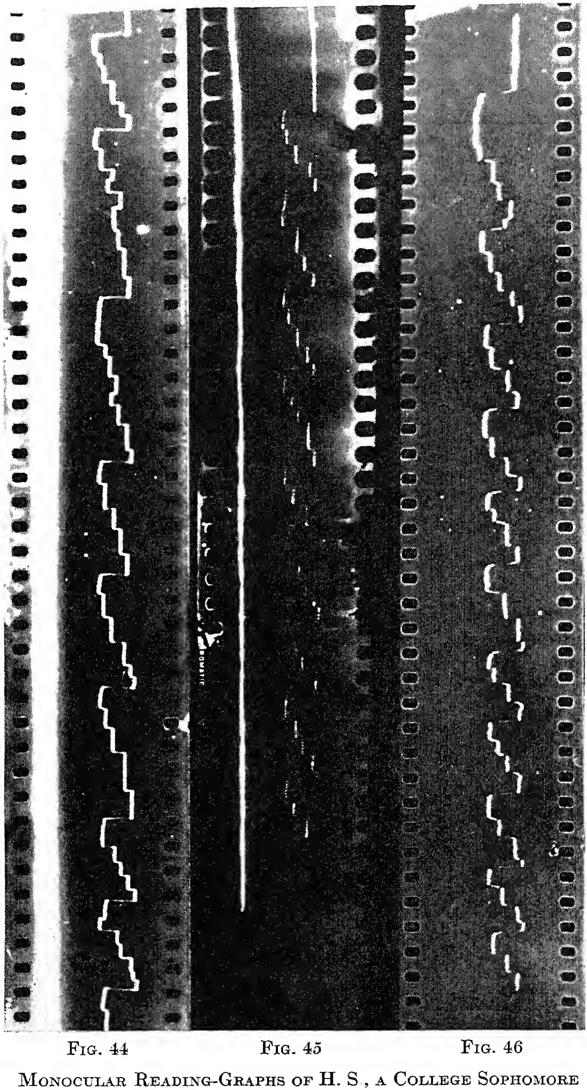


FIG. 44 FIG. 45 FIG. 46

MONOCULAR READING-GRAPHS OF H. S., A COLLEGE SOPHOMORE

FIG. 44.—Before training in controlled reading. FIG. 45.—After nine thirty-minute practice periods. FIG. 46.—Six months after the training was completed.

of recognition, observed at the end of the training period, is a relatively permanent improvement. The apparent loss in comprehension is explained by the fact that the reading material used at this time was more difficult than that used at the end of the training period.[7]

Plates LXXIII and LXXIV contain photographic records of the eye-movements of C. B. and H. S. before training, at the end of the training period, and six months after the end of the training period. The rhythm of the reading in Figures 43 and 46 is very noticeable.

The data indicate that training on the Metron-O-Scope tends to broaden the span of recognition, and this improvement is accompanied by a decrease in the number of fixations and regressions per line. Reading with fewer fixations and regressions, and with a rhythmic left-to-right movement, the subjects score as high in comprehension on material presented in the Metron-O-Scope as they do in reading from a book at a slower speed. A comparison of the records of eye-movements made at the end of the training period and six months later indicates that in terms of increased functional efficiency the improvement is relatively permanent.

[7] As determined in a study where the same material was used with fifty subjects.

CHAPTER X

DIAGNOSIS AND CORRECTION OF READING DEFICIENCIES IN HIGH SCHOOL

This study was a continuation of the research carried on by means of eye-movement photography to determine: (*a*) whether controlled reading with the Metron-O-Scope[1] is more effective in establishing efficient reading habits than a corrective method which depends principally on verbal instruction, and (*b*) whether the improvement brought about by training is permanent.

Fifty subjects from the tenth and eleventh grades in high school participated in the experiment. Before beginning the experimental work the eye-movements of all the subjects were photographed while they read from the camera cards.[2] The cards were divided into two series of three cards each and numbered,[3] and during the

[1] The instrument used is shown on p. 144.

[2] The selections were from the story of Aladdin and a chapter in history relating to the travels of Marco Polo.

[3] One series was numbered 1, 2, 4, and the other 1, 3, 5. No. 1 in each series was a practice selection, but the material on the two cards was not the same. About half of each group read 1, 2, 4 during the preliminary photography, and the other half read 1, 3, 5. At the end of the training period this arrangement was reversed, each group reading from the other series.

experiment all the subjects read from all the cards, thus making the data comparable. Each subject, before he began to read, was instructed to read as rapidly as possible and yet with sufficient comprehension to enable him to answer questions on the material read. After he had finished the practice selection, which was utilized to acquaint him with the experimental technique, he read from the other two cards while his eye-movements were recorded. When the eye-movement records were available, the investigator talked to the subjects in a group, comparing their reading-graphs with those of an excellent reader. In this way they became familiar with the technical terms used in eye-movement photography, and the characteristics of efficient and inefficient reading.

For the experimental work the subjects were divided into two groups containing twenty-five subjects each, a control group consisting of thirteen boys and twelve girls and an experimental group consisting of ten boys and fifteen girls. The two groups were arranged so that they had about (*a*) the same average grade in four and a half months of school work, (*b*) the same average I.Q. on the basis of the Otis Self-Administering Test of Mental Ability, and (*c*) the same standing on both parts of the Iowa Silent Reading Test. The reading ability of the subjects, as indicated by the number of fixations and regressions

shown in the preliminary reading-graphs, was also taken into consideration in the grouping.

Table XI is a comparison of the data for the two groups obtained from the preliminary testing. The reading data are based on 148 words of reading material, and the time shown is the average number of seconds required by each

TABLE XI

READING DATA ON TWO GROUPS OF HIGH-SCHOOL STUDENTS BEFORE TRAINING WITH THE METRON-O-SCOPE

Nature of Data	Experimental Group Means	Sigma of Distribution	Control Group Means	Sigma of Distribution
Average grade for four and one-half months	85.24 ± .88	6.53	83.68 ± .94	7.00
I.Q.	106.04 ± 1.55	11.52	107.24 ± 1.73	12.84
Iowa T.C.S.	130.88 ± 5.07	37.50	132.53 ± 5.46	40.48
Iowa R.S.R.	27.80 ± 1.25	9.32	27.24 ± .90	6.63
Fixations 148 words	116.04 ± 3.37	24.94	120.08 ± 2.14	15.92
Regressions 148 words	14.68 ± 1.04	7.72	14.8 ± .96	7.17
Comprehension	83.33 ± 1.63	12.08	86.33 ± 1.49	11.03
Time	31.65 ± 1.18	8.75	33.84 ± 1.13	8.36

group in reading the two selections while the eye-movements were being photographed. The average number of fixations and regressions is about the same for each group. Apparently, at the beginning of the experiment there was little difference in the ability of the two groups, in terms of the test items.

The practice periods were held after school hours, every afternoon for two weeks, so that

each group had ten practice periods of thirty minutes each. All the subjects completed the training, so that the data gathered before and after training were comparable.[4] During the daily practice period the groups were in adjoining rooms, and the physical conditions were practically identical. All the subjects were instructed, at the beginning of each practice period, to read as rapidly as possible but with sufficient comprehension to answer questions on the material read, at the same time making an effort to read with not more than three fixations to a line of print and with no regressive movements. All the subjects were asked also to practice this new technique on some reading selection every day. The same material[5] was used for both groups, but the control group read from mimeographed sheets, while the experimental group read from the Metron-O-Scope. Under these conditions,

[4] The subjects were induced to attend regularly by appealing to their ambition to become better readers, and also by giving each of those present at the daily practice period a small favor—a popcorn ball, a movie ticket, candy, etc. Prizes were offered at the end of the training period. Those with perfect attendance records could draw for a $5.00 prize; those who had missed only one practice period for both $3.00 and $2.00 prizes; and those who had missed more than one practice period for a $2.00 prize. The few absences which occurred were made up at study periods during the days following the absence.

[5] Barrett H. Clark and Maxim Lieber, *Great Short Stories of the World* (New York: Robert M. McBride & Co., 1925). Pp. xv+1072.

the corrective work with the control group consisted of intensive practice of reading habits already established, with verbal instructions as to how they might be improved. Controlled reading with the Metron-O-Scope, on the other hand, created an entirely new reading situation in which the experimental group was forced to practice new habits of attack on print. Thus old habits were broken down and new ones established.

The Metron-O-Scope presented the material at the rate of about two hundred words per minute during the first practice period, and this was increased gradually to approximately four hundred words per minute. The control group, however, read from the mimeographed sheets at their own individual rates. As soon as each member of the control group finished the reading selection, he turned the mimeographed sheet face down, and waited quietly for the slips carrying the questions to be distributed. When all the subjects had finished the reading assignment, comprehension was checked in both groups by means of four written questions. These tests were collected as each subject finished, and later were scored by the investigator. After all the tests had been collected, the questions were discussed and the subjects immediately re-read the material in the daily assignment to check their own answers.

At the end of the training period the eye-movements were again photographed, and the subjects were given the same type of tests that had been used as a basis for grouping before the experiment began. Table XII is a comparison of the data obtained at this time. The experimental group averaged fewer fixations and regressions

TABLE XII

READING DATA ON TWO GROUPS OF HIGH-SCHOOL STUDENTS AFTER TRAINING WITH THE METRON-O-SCOPE

Nature of Data	Experimental Group Means	Sigma of Distribution	Control Group Means	Sigma of Distribution
I.Q.	109.92 ± 1.69	12.55	112.32 ± 1.43	10.60
Iowa T.C.S.	139.84 ± 5.22	38.69	143.50 ± 5.96	44.13
Iowa R.S.R.	34.68 ± 1.23	9.17	33.40 ± 1.04	7.68
Fixations 148 words	92.68 ± 2.44	18.11	100.28 ± 2.35	17.45
Regressions 148 words	6.84 ± .80	5.96	11.28 ± .81	6.00
Comprehension on camera	82.00 ± 1.90	14.07	84.66 ± 2.00	14.85
Time reading from camera	22.16 ± .76	5.66	24.24 ± .64	4.79

per 148 words than the control group, presumably as a result of controlled reading. The increase of speed in silent reading is also greater for the experimental group, and the loss in comprehension—shown for both groups and apparently due to reading too rapidly—is smaller.

Table XIII is a comparison of the data shown in Table XI and Table XII. The apparent gain

in I.Q., which is shown for both groups, indicates that the group test used is influenced by both reading ability and reaction time and is not valid, therefore, solely as a test of mental ability.[6] Within the groups the differences shown are statistically reliable, but in comparing the two groups the reliabilities of the differences are not so marked, except with reference to fixations and regressions.

In terms of fixations we notice that there is a change in the average of the experimental group of 23.36 fixations, or a decrease of 20.13 per cent in reading 148 words, whereas the change in the average of the control group is only 19.80 per 148 words, or a decrease of 16.48 per cent. The fact that the material in each window is obscured as soon as it is read also tends to discourage regressive movements. Theoretically, of course, it is possible to read without any regressions. Table XII shows a decrease in the average number of regressions for the experimental group of 7.84 or 53.40 per cent, whereas the decrease in the average number of regressions for the control group is 3.52 or 23.78 per cent. The reliability of this difference is 99.5. The decided difference in the average number of regressions made by the two groups, and the fact that this difference is highly reliable, indicate that controlled reading with the

[6] Cf. p. 247 n.

Metron-O-Scope does tend to decrease the number of regressive movements.

The decrease in the number of fixations and regressions is accompanied by an increase in speed in both groups. Before training, the experimental group read an average of 280.58 words per minute, and, as a result of the training, increased this to 400.72 words per minute, which is an improvement of 42.83 per cent. The control group read 262.37 words per minute before training and increased this to 366.33 words per minute, which is an improvement of 39.62 per cent. Considering the methods of presenting the material, one would expect a decided difference between the average comprehension scores on the two groups, but there is a difference of only 1.15 points. The average score for the experimental group is 78.69 and for the control group, 79.84. This is all the more surprising in view of the fact that the experimental group had been forced to read at a uniform rate, the speed being increased gradually as the experiment progressed.

In order to determine the permanency of the improvement in reading ability brought about by this type of training, the eye-movements of all the subjects were photographed again one month after the end of the training period. As usual, the subjects were told to read as rapidly as they could, but with sufficient comprehension

TABLE XIII

Composite Table—Data before and after Training for the Two High-School Groups

Mean	I.Q.	Iowa T.C.S.	Iowa R.S.R.	Fixations 148 Words	Regressions	Comprehension	Time
Experimental:							
Before......	106.04 ± 1.55	130.88 ± 5.07	27.80 ± 1.25	116.04 ± 3.37	14.68 ± 1.04	83.33 ± 1.63	31.65 ± 1.18
After.......	109.92 ± 1.69	139.84 ± 5.22	34.68 ± 1.23	92.68 ± 2.44	6.84 ± .80	82.00 ± 1.90	22.16 ± .76
σ:...........							
Before......	11.52	37.50	9.32	24.94	7.72	12.08	8.75
After.......	12.55	38.69	9.17	18.11	5.96	14.07	5.66
Control:							
Before......	107.24 ± 1.73	132.53 ± 5.46	27.24 ± .90	120.08 ± 2.14	14.8 ± .96	86.33 ± 1.49	33.84 ± 1.13
After.......	112.32 ± 1.43	143.50 ± 5.96	33.40 ± 1.04	100.28 ± 2.35	11.28 ± .81	84.66 ± 2.00	24.24 ± .64
σ:							
Before......	12.84	40.48	6.63	15.92	7.17	11.03	8.36
After.......	10.60	44.13	7.68	17.45	6.00	14.85	4.79
Experimental reliabilities of the differences	87	100	99.6	100	100	100	64

*

TABLE XIII—*Continued*

Mean	I.Q.		Iowa T.C.S.		Iowa R.S.R.		Fixations 148 Words		Regressions		Comprehension		Time	
Control reliabilities of differences.....	93		83		99.9		99.2		97		100		67	
Reliabilities of differences between experimental and control groups......	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
	82	56	62	60	60	71	76	93	52	99.5	82	92	82	73

to answer questions on the material read.[7] The data gathered at this time (Table XIV) show that the standard deviations and the probable errors of the differences for the experimental group are all smaller than those for the control group. Another interesting point is that the averages for the experimental group, in terms of fixations, regressions, speed, and comprehension, show greater retention of the effects of the training than do the averages for the control group. The reliabilities of the differences shown in the last line of Table XIV should also be noted, particularly those between the two groups. In observing these data it is well to keep in mind that the improvements shown are the result of *ten practice periods only*, whereas the reading habits of the subjects had been in formation for at least ten years. From the data on speed and comprehension it seems obvious that the reading selections used at the end of one month were more difficult than those used during the earlier photography, yet the experimental group read at an average rate of 331.83 words per minute, and scored higher on comprehension than the control group which read at an average rate of 310.92 words per minute. The fact that the reading

[7] The selections read at this time contained 172 words, but the results were tabulated on the basis of 148 words so that all the data would be comparable.

TABLE XIV

COMPOSITE TABLE SHOWING PERMANENCY OF RESULTS OF TRAINING WITH THE METRON-O-SCOPE

Mean	Fixations	Regressions	Comprehension	Time
Experimental group:				
Before training	116.04 ± 3.37	14.68 ± 1.04	83.33 ± 1.63	31.65 ± 1.18
After one month	108.40 ± 2.52	11.96 ± .86	80.33 ± 1.85	26.76 ± .65
σ:				
Distribution before training	24.94	7.72	12.08	8.75
After one month	18.67	6.36	13.68	4.86
Control group:				
Before training	120.08 ± 2.14	14.8 ± .96	86.33 ± 1.49	33.84 ± 1.13
After one month	114.00 ± 3.70	15.84 ± .94	71.66 ± 2.35	28.56 ± .83
σ:				
Distribution before training	15.92	7.17	11.03	8.36
After one month	22.41	6.98	17.46	6.17
Reliabilities of differences in experimental group	89	93	79	99.3
Reliabilities of differences in control group	89	69	87	99.7
Reliabilities of differences between experimental and control groups	83	98	98	88

material was more difficult would account, in a measure, for the apparent loss in training that is shown for the experimental group at the end of one month. It is interesting to observe, however, that the experimental group retained some degree of improvement in every item, whereas the control group made more regressions at the end of one month than they did *before* training. This fact and a study of the reading-graphs indicate that, as far as the control group is concerned, the training simply shortened the reaction time with little apparent change in their reading habits.

A correlation was run for both groups between fixations before training and fixations a month after the end of the training period. The coefficient of correlation for the experimental group was .548 ± .099, and for the control group .678 ± .65. A correlation for both groups between regressions before training and regressions one month after the end of the training period shows a coefficient of correlation for the experimental group of .323 ± 1.27 and for the control group of .618 ± .087. These figures also support the belief that little apparent change occurred in the reading habits of the control group. The low coefficient of correlation for fixations for the experimental group, and an almost total absence

of correlation for regressions, seem to indicate that there was considerable stirring-up in this group, owing to the training with the Metron-O-Scope.

To place all the items on a comparable basis and permit the study of individual cases, all the data were calculated in terms of the standard deviation. The differences already mentioned were verified, and in some instances it was found that the differences were even greater. One of the most important findings from this comparison was that the subjects in the experimental group, regardless of the I.Q. indicated by the mental test, were practically all benefited by the training.[8] The corrective method used with the control group, however, only benefited those with a high I.Q.

The result of this experiment, then, from the standpoint of the control group, somewhat parallels the result of our present system of teaching reading. The pupil with a high I.Q. usually learns to read fairly well, while one with a low I.Q. may continue to read slowly and inefficiently if he is not given a great deal of individual atten-

[8] The results of the research now in progress in the reading clinics supervised by Dr. Louise Farwell at the National College of Education, Evanston, Illinois, and Dr. Stella S. Center at Roosevelt High School, New York City, corroborate these findings.

tion. These poor readers, generally, are the failures and problem cases.

Figures 47–52 are typical of the reading-graphs of subjects in the experimental group. Figures 53–58, which show lack of any marked change in rhythm and regularity of reading, are typical of those in the control group. Three graphs are shown for each subject—one taken before training, one at the end of the training period, and one a month later. These reading-graphs clearly show the difference in rhythm and regularity of eye-movements between subjects trained with the Metron-O-Scope and those who have not had this training. Figures 47, 48, and 49 are the reading-graphs of a young man who was a fairly good reader before training, but who improved decidedly in both speed and rhythm. The training apparently raised his I.Q.[9] from 107 to 117. Figures 50, 51, and 52 are the reading-graphs of a young woman. There was no apparent change in the I.Q., which was 92 before and after training, but the graphs show marked improvement in the reading habit. The reading-graphs of the young woman in Figures 53, 54, and 55 were characterized by an increase in the number of fixations and less rhythm and regularity than in the two former cases. In this case the I.Q. apparently dropped from 129 to 124. Figures 56, 57, and 58 are the reading-graphs of a

[9] Cf. p. 247.

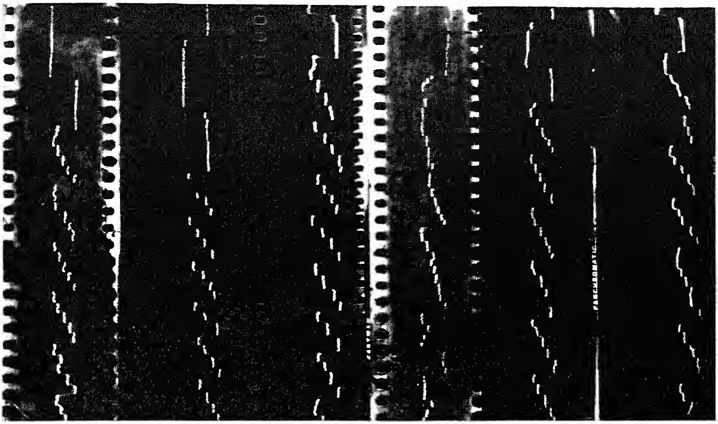


FIG. 47 FIG. 48 FIG. 49 FIG. 50 FIG. 51 FIG. 52

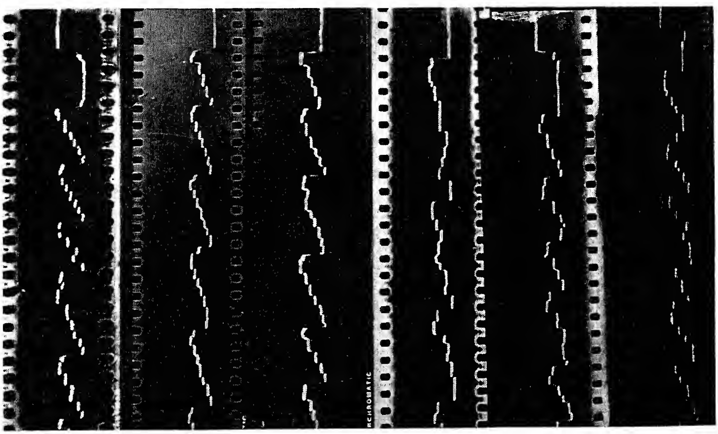


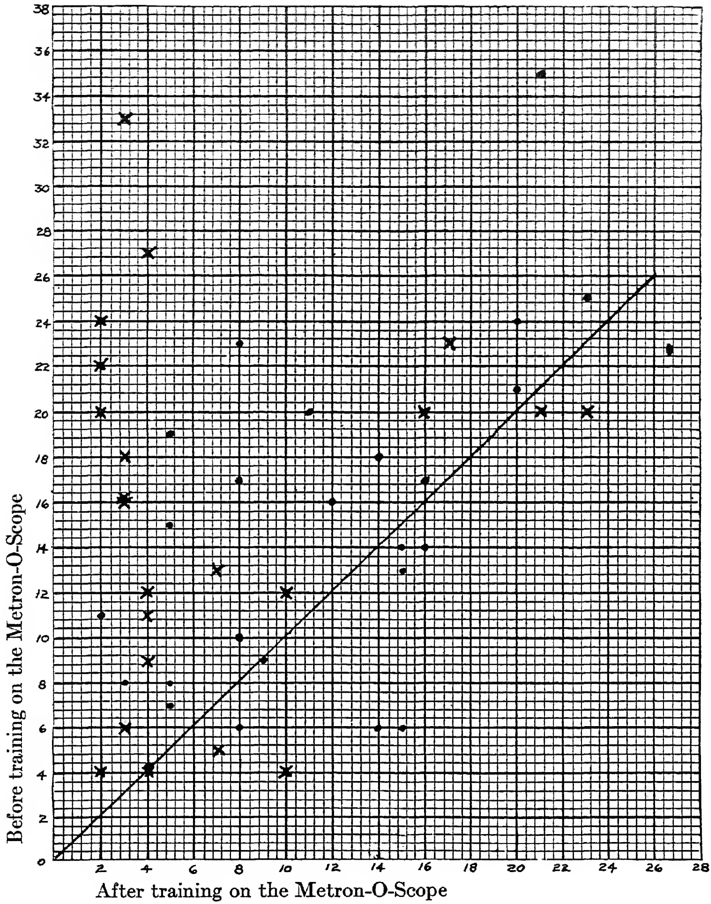
FIG. 53 FIG. 54 FIG. 55 FIG. 56 FIG. 57 FIG. 58

Figures 47–52 are typical of the reading-graphs of subjects in the experimental group, Figures 53–58 of those in the control group. Figures 47, 50, 53, and 56 were taken before training; Figures 48, 51, 54, and 57 at the end of ten practice periods; and Figures 49, 52, 55, and 58 one month after the training was completed.

young man whose apparent I.Q. was 103 before training and 106 after training. He reads with little improvement in the general eye pattern, but with shorter fixation time than before training. This type of reading seems to be characteristic of the control group.

As the possibility of decreasing the number of regressions by this type of controlled reading is much greater than the possibility of decreasing the number of fixations, Plates LXXVI and LXXVII are of interest. They represent graphically the regressions made by each group before training, immediately after training, and one month after the end of the training period. Attention is again called to the fact that these data are based on the results of ten practice periods only. The experimental group is designated by an *X* and the control group by a dot. The vertical axis in each figure represents regressions before training. The horizontal axis in Plate LXXVI represents regressions immediately after training, and in Plate LXXVII regressions one month after training was completed. The graphs show that more subjects in the experimental group than in the control group were above the 45° line after training.

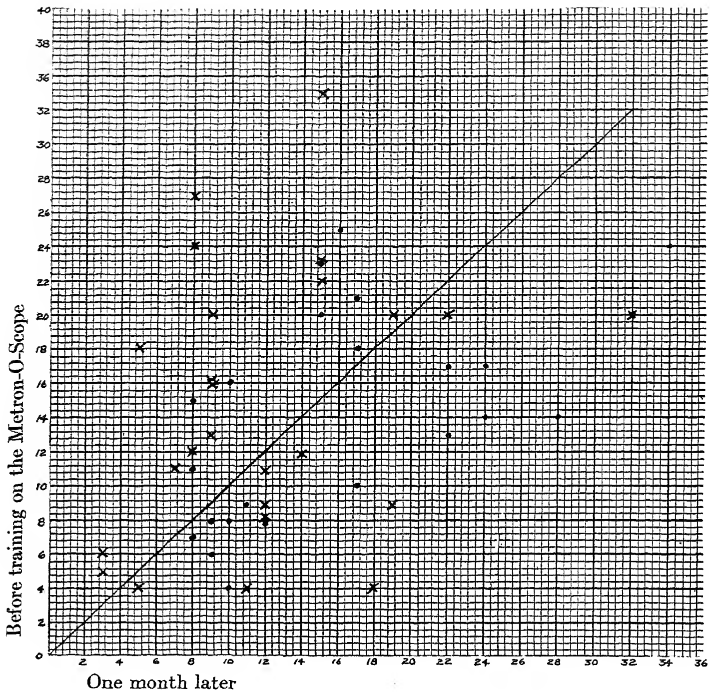
A comparison of the experimental data for the two groups in this study indicates that controlled reading with the Metron-O-Scope aids materially



REGRESSIONS BEFORE AND AFTER TRAINING IN CONTROLLED READING

X Experimental group
• Control group

PLATE LXXVII



Regressions before Training in Controlled Reading and One Month after the Completion of the Training

X Experimental group
• Control group

in decreasing the number of fixations and regressions per line of print, and that these improvements are relatively permanent. This improvement in the efficiency of reading is no doubt due to the conditioned increase in the span of recognition and the increased functional efficiency of the individual in reaction to print.

The findings in this study also indicate that the willingness of the pupil to follow verbal instructions is not effective in breaking down old habits and establishing new ones. The response of the subjects in the experimental group, however, to a reading situation in which they were compelled to practice new habits of attack on print is evidence that corrective training of this type tends to condition rapid, efficient reading.

CHAPTER XI

DUCTION[1] AND FUSIONAL TRAINING IN READING

This paper reports a study of fusion in reading, as influenced by binocular imbalances. A short discussion of fusion[2] is given in an effort to show its close relationship to the reading process.

In this discussion "fusion" is the term that describes the merging in the brain centers of the neural impulses coming from the stimulation of both retinas in such a way that, although an image is recorded on each retina, we are aware of only one object. Fusion, as here used, is independent of stereopsis, or the illusion of depth. It has been demonstrated that stereopsis is not the peak of fusion, because many individuals with excellent fusional ability have poor depth perception, as measured by ordinary tests,[3] while others, who have excellent depth perception, have difficulty in maintaining binocular single

[1] Power of the extrinsic muscles of the eyes to maintain binocular single vision under stress.

[2] Dr. Verhoeff prefers the term "unification" ("A New Theory of Binocular Vision," *Archives of Ophthalmology*, XIII, 152).

[3] William B. Barker, "Binocular Vision," *British Journal of Physiological Optics*, X (April, 1936), 64–72.

vision. On the other hand, fusion is essential in binocular stereopsis.[4]

With some individuals fusion may take place slowly, as the result of functional inco-ordination. With others, there may be fusion in varying degrees, influenced by the nature and intensity of the stimulus, and the refractive condition. Individual variations result in a wide range of fusional ability.

Fusion, as such, probably results from the innate desire of the human organism to see singly, and it is therefore influenced by convergence, accommodation,[5] and perhaps the dominance of one visual brain center. First, binocular single vision demands a fair balance between the six pairs of muscles[6] governing eye-movements. This balance insures the necessary convergence so that light rays coming from an object strike the retinas in corresponding zones, otherwise diplopia, or double vision, results. Second, the process of accommodation must be functioning in such a way that the light rays to the retinas are brought to a focus. With many individuals

[4] Some investigators claim that there are cases of monocular depth perception but this is probably a learned reaction in which the subject judges distance and depth by shadows, peculiar atmospheric conditions, overlapping of objects, sizes of objects, etc.

[5] The process by which the light rays are brought to a focus on the retina for clear vision.

[6] The interni recti, externi recti, superior recti, inferior recti, superior oblique, and inferior oblique muscles.

this process is exceedingly slow. Subjects also are found who have an unequal amount of accommodation in the two eyes. As a result of these irregularities rapid, accurate reading may be impossible until remedial work is done. Third, it seems plausible to assume, in light of the present theories concerning brain activity, that one hemisphere of the brain is dominant. If this is so, it may be that the degree of dominancy has some influence upon the rapidity of formation of the single binocular percept. The rapidity and ease with which the merging of neural impulses takes place, however, are within all probability dependent to a great extent upon the co-ordination existing between convergence and accommodation. If the convergence of the two eyes does not function adequately, or the vision of either eye is impaired, it is obvious that the merging of the two retinal images will be slower than normal, and it may be that suppression of vision[7] in one eye must take place to avoid diplopia.[8] In making this compensatory reaction the suppressed eye generally deviates from the normal position so as to lessen the fusional conflict. If the deviation is excessive, there is a total absence of fusion and the condition is designated as a "squint" or "strabismus."[9] If this condition exists for any length of time, impaired vision

[7] Cf. p. 163. [8] Cf. p. 165.

[9] Cross eyes of the convergent, divergent, or vertical type.

generally follows and even pronounced amblyopia[10] may result.

A high percentage of the total population suffers from some form of binocular imbalance, and it is logical to assume that this binocular imbalance must influence in some degree the formation of reading habits suited to the best fusion for an individual. This may be one of the causes for the great individual variability shown in the reading habits of school children and adults. Here we are not so much interested in what causes this imbalanced condition of the eyes as we are in the fact that the individual affected seldom has, except by an excessive dissipation of neural energy, the proper ocular orientation in reading; and that in many cases the functional irregularities result in eye discomfort. Figure 59 shows the *oculus dexter*[11] and *oculus sinister*[12] in emmetropia.[13] In this figure the optically perfect eye (rare) is shown in the act of convergence, fixing at the near-point with a perfect balance between the externi and interni recti muscles. The light rays come to a focus on the macula[14] on each

[10] Diminished visual acuity (cf. p. 163).

[11] The right eye. [12] The left eye. [13] Cf. p. 168.

[14] Macula: the small yellow spot of the retina which lies directly in the visual axis. It is about 4 mm. to the temporal side of the center of the optic disk, in the horizontal meridian, and is less than 2 mm. in diameter. A depression in its center, fovea centralis, is the most sensitive point of vision (James J. Lewis, Oph.D., *Pocket Ophthalmic Dictionary and Encyclopedia* [8th ed., rev. and enl.]).

PLATE LXXVIII

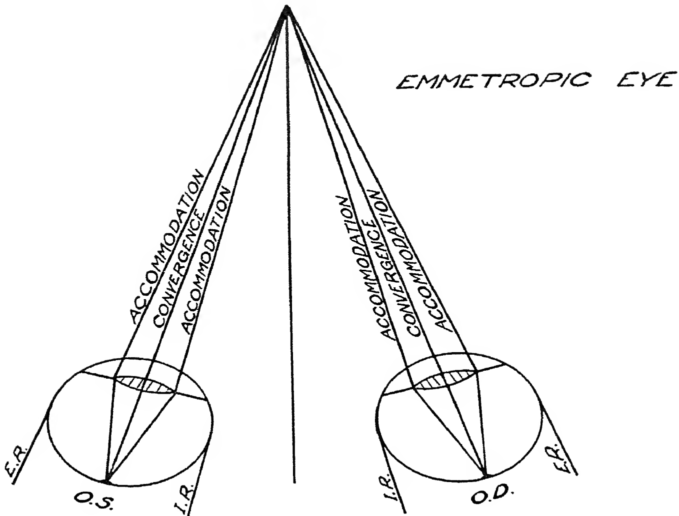


FIG. 59

REPRESENTATION IN DIAGRAMMATIC FORM OF THE EMMETROPIC OR NORMAL EYE

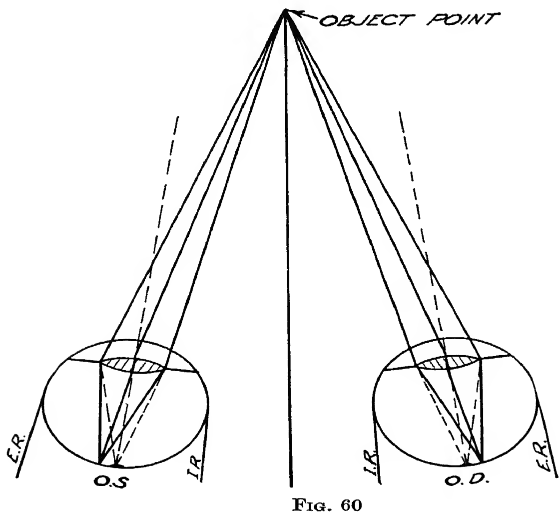


FIG. 60

REPRESENTATION IN DIAGRAMMATIC FORM OF AN EYE WITH CONVERGENCE INSUFFICIENCY

eye, designated by the small black oval. This is the spot of clearest vision, where the light rays always tend to come to a focus. Figure 60 is used to facilitate a discussion of a type of visual inefficiency which may influence reading ability. In the diagram the convergence function is deficient from weakness, fatigue, or lack of adequate neural stimulation. The visual axes (indicated by the dotted lines) are underconverged and meet beyond the object point. If the eyes were overconverged, the axes would meet in front of the object point. The condition as shown in Figure 60 probably cannot exist, except experimentally, and certainly it is not implied that such a state can exist statically. This condition would probably result in a fixing of one eye on the object point, with a consequent suppression of the other eye, in order to produce clear vision and avoid diplopia. In chapter iv it is observed that, in reading, irregularities of the two eyes are marked in many cases. Examples of both overconvergence and underconvergence are shown. It is noted also that, in compensating for these irregularities, various corrective adjustments of the eyes occur. For instance, at the beginning of each new line of printed material, where overconvergence is apparent, the next adjustment is a regression which probably indicates inaccurate perception on the first fixation. This time-consuming activity not only slows the rate of reading, but tends to bring on fatigue.

An attempt has been made to explain fusion in its relationship to reading, as conditioned by certain factors which probably influence the total process. It is necessary also to explain the technique used to increase ductions. The primary object in orthoptic training of any type is to bring about comfortable vision. There is no way of determining exactly what changes occur in the visual apparatus while this result is being brought about, but extensive experimental work and the experience of those who are using the controlled-reading technique explained in the next chapter indicate that the binocular imbalances (phorias) as measured when the eyes are dissociated do not seem to be as important a factor as the nature and quality of the compensatory mechanism indicated by the duction. In many instances it is found that the phorias do not necessarily change a great deal as the result of the controlled reading training, yet the subject may have perfectly comfortable vision after the duction power has been increased. In other words, it would seem that if "the duction is capable of coping with the phoria"[15] the subject is quite likely to have comfortable vision, provided, of course, that there are no other complicating factors.

Figure 61 shows in diagrammatic form the

[15] L. A. Swann, *The Ocular Muscles and the Treatment of Heterophoria and Heterotropia*, p. 63. London: Hatton Press, Ltd., 72–78 Fleet St., E.C. 4., 1931.

PLATE LXXIX

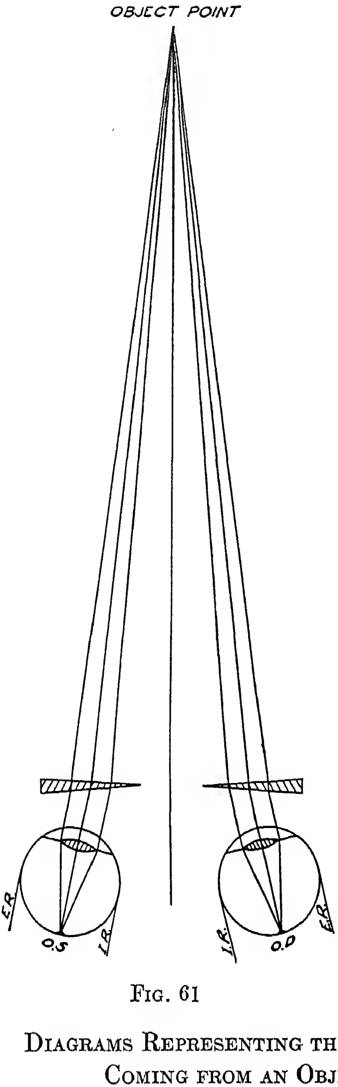


FIG. 61

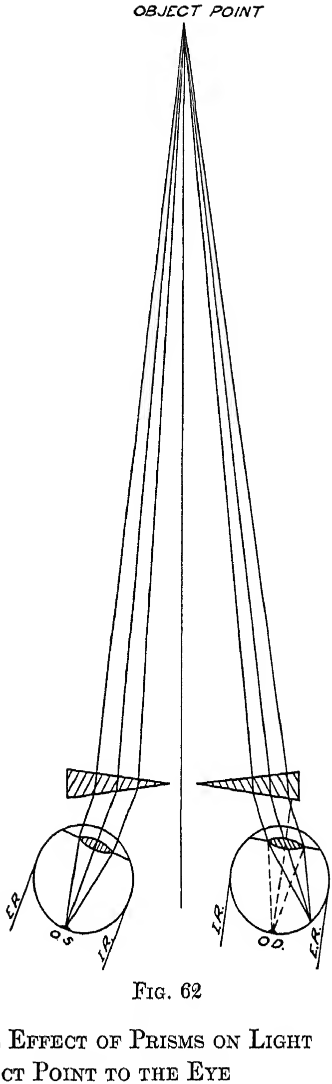


FIG. 62

DIAGRAMS REPRESENTING THE EFFECT OF PRISMS ON LIGHT COMING FROM AN OBJECT POINT TO THE EYE

normal response of light from an object point to prisms placed over the eyes base-out, and Figure 62 shows the eyes after the prism power has become so great that the interni recti muscle in the right eye relaxed. The right eye, consequently, diverged and diplopia occurred. Prisms placed over the eyes base-in cause them to diverge, and in this way the reaction of the externi recti muscles can be measured; while prisms base-out cause the eyes to converge, and in this way the reactions of the interni recti muscles can be measured. Risley rotary prisms, attached to a De Zeng Phorometer, were used in checking the eye-muscle reactions in this study and in giving the corrective work.[16] The reaction of the eye muscles in prism diopters was secured by placing the prisms over the eyes and rotating them, base-in and base-out, in the same degree until diplopia was produced, while the subjects read indicia presented in the Metron-O-Scope (technique described in chap. vii). In this type of test the sum of the readings on the prisms represents the total capacity of the eye muscles to maintain single binocularity under stress. Static tests are made sometimes by using a prism over one eye only, but for checking eye-muscle reactions to obtain

[16] The use of loose prisms is not recommended for these exercises, because too much time is wasted in changing the prism power, and the effect on the subject is to discourage concentration on the work being done.

a reading-ratio this procedure is not considered advisable,[17] as head movements may be sufficient to affect the validity of the test.

The beneficial results obtained by the use of prism exercises have been known to eye specialists for many years. The exercises have been given in many ways, but the most effective results can be obtained when prisms are placed over the eyes and the power increased up to the blur point, while the subject watches a moving object or moves his eyes from one object to another. In a short time the vision clears somewhat as the eyes adjust, and the subject is then ready for more prism power. A continuation of these exercises gradually conditions a qualitative or quantitative increase in the duction power and more effective eye co-ordination. Various types of prism exercises have been used in attempting to correct certain visual anomalies. Prism-reading with the Metron-O-Scope is the first technique, however, in which the practice of efficient reading habits is combined with eye-muscle exercises designed to condition binocular co-ordination and produce comfortable vision. It is the first attempt to condition eye habits that are fundamental to efficient reading, and that the subject continues to use after the training ceases.

[17] Swann, *op. cit.*, pp. 68–70.

After the Metron-O-Scope had been used successfully for correcting inefficient eye habits in reading, an experiment was undertaken to determine whether more beneficial results could be obtained in some instances by the use of prisms in conjunction with the instrument.[18] It seemed reasonable to suppose that increased functional efficiency of the visual mechanism could be brought about by this controlled reading technique.

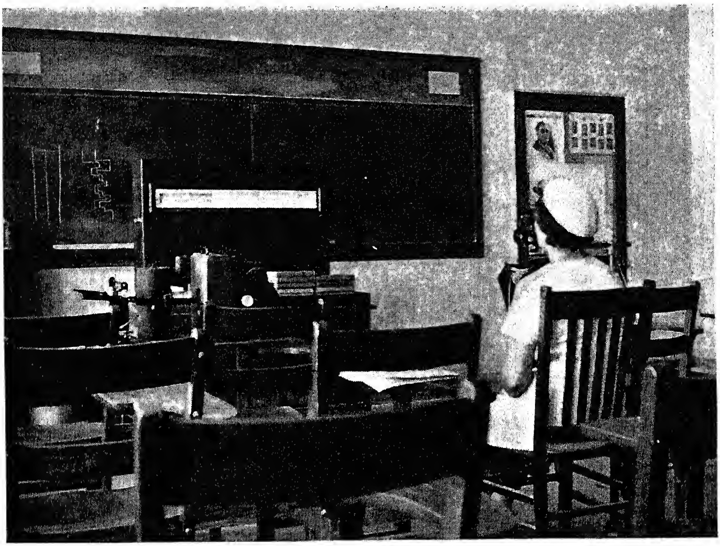
To test this hypothesis prism-reading was given for a time to two high-school students from the Austin High School and a graduate student from the University of Texas, in order to discover whether they would show desirable changes in their reading habits. The three subjects, two boys and a girl, had astigmatic errors. The girl was wearing cylindrical lenses and the boys were wearing compound lenses.[19] All complained of headaches or eyestrain in near-point work. They had poor reading-ratios to begin with, as is shown in the first line of Table XV.

Before the prism-reading exercises were started, the reading-ratios were obtained, and the eye-movements of the subjects were photographed

[18] Cf. pp. 245, 253, and 274.

[19] Compound lenses consist of two or more lenses, made up together as one lens, such as a sphere combined with a cylinder. The boy with hyperopia wore strong plus spheres with cylinders; and the other boy wore weak minus spheres with a cylinder.

PLATE LXXX



First Subject To Take Prism-reading, Using an Early Model of the Phorometer

In the left background is the first portable eye-movement camera and an early model of the Metron-O-Scope.

while they read two selections, consisting of 148 words in all. The two high-school students were given also the Otis Self-administering Test of Mental Ability. Each subject was trained twice a day for a period of fifteen to twenty minutes. At each daily period the subjects read for three to five minutes from a roll of heterogeneous words presented on the Metron-O-Scope, followed by short stories presented on the instrument.

The two boys were given both base-in and base-out exercises, but the girl's externi recti muscles reacted so strongly that she was given only the base-out training. During the training period an attempt was made to produce a four-to-one ratio between the interni and externi recti eye muscles.[20] In other words, an attempt was made to train the interni recti muscles to give four times the reaction, in prism diopters, of the externi recti muscles, or to condition a $10^{\Delta}/40^{\Delta}$ reading-ratio. This could not be secured with all the subjects but desirable changes occurred in all the cases studied. Preliminary experimenta-

[20] Authorities differ as to what the reactions of the interni and externi recti muscles should be. Some say that they should be in the ratio of $8^{\Delta}/50^{\Delta}$, that is, the reactions of the externi recti muscles or the abduction should be eight prism diopters and the reaction of the interni recti muscles, or adduction, should be fifty prism diopters. Others say that the ratio should be $8^{\Delta}/24^{\Delta}$, or from 4^{Δ} to 8^{Δ} over 20^{Δ} to 30^{Δ}, at a distance of 6 m. Still others hold that $10^{\Delta}/40^{\Delta}$ is desirable.

TABLE XV

Composite Table—Data on Three Subjects, before and after Training, in the Preliminary Study of Prism-reading and on Twenty-five Subjects Who Did Not Receive Training*

Subject	J. D. R. Twenty Periods		J. R.		G. S.		Twenty-five Other Students
Reading-ratio	Before $6^{\Delta}/14^{\Delta}$	After $10^{\Delta}/42^{\Delta}$	Before $5^{\Delta}/22^{\Delta}$	After $10^{\Delta}/31^{\Delta}$	Before $16^{\Delta}/20^{\Delta}$	After $10^{\Delta}/39^{\Delta}$	.....
Fixations	131	119	112	98	143	134	116.04 ± 3.37, σ 24.94
Regressions	24	14	5	6	13	8	14.68 ± 1.04, σ 7.72
Comprehension	50	83.33	91.66	83.33	50	75	83.33 ± 1.63, σ 12.08
Time	34.31	26.57	26.25	21.89	35.63	26.89	31.64 ± 1.18 sec., 8.75
Words per minute	259	334	338	406	249	330	281
I.Q.†	.....	.....	93	107	88	102	104.04 ± 1.55, σ 11.52

* The second group (twenty-five subjects) read the same selection that was used for the preliminary photography of the eye-movements of the three subjects. A new selection of the same difficulty was used for the photography of the eye-movements of the three subjects at the end of the training period.

† In the experimental work it was found that inefficient readers with a low I.Q., according to the Otis test, gain from a few points to as high as twenty points on this test after they have received training in controlled reading with the Metron-O-Scope. A study of the school grades of these subjects showed an improvement in general scholarship.

tion seemed to indicate that this ratio secured comfortable vision in near-point work, but no hard and fast rule can be made because individual variation in compensatory ability is a factor to be taken into consideration. A careful check of the reading-ratio was made at the beginning of each practice period. At the end of ten practice periods the high-school students were given another form of the Otis Test and their eye-movements were photographed, but the eye-movements of the university student were not photographed[21] until he had completed twenty practice periods.

Table XV contains the data on all the items studied. In the last column the data are the averages, in the items listed, for a group of twenty-five students who did not have prism-reading exercises. Their eye-movements were photographed while they read the selections used in the preliminary photography of the three subjects who had the training. Comparison of the data for the three subjects shows that one of them was above the average in reading ability before training, while the other two were below average in terms of most of the items studied. It is interesting to note that during the training the three subjects made appreciable gains in all

[21] The reading material used at this time was of the same difficulty as that used in the preliminary photography.

items, except J. R., who made one more regression.

Figures 63, 64, 65, and 66 are the reading-graphs of the two high-school students before and after training. It is seen that there was an improvement in the rhythm and efficiency of the reading during the training period. One of the most interesting facts brought out is that the subjects reported comfortable vision, and were pleased with the results of the training. The success of this experiment suggested the possibility that a properly developed technique of prism-reading could be used in remedial reading work not only in reading clinics in educational institutions but in the office practice of eye specialists, for those cases who cannot respond to classroom procedures because of certain functional deficiencies of the visual apparatus. An intensive investigation was made, therefore, of the literature in the fields of ophthalmology, optometry, and education to find out if any similar technique had been developed. At the time of this investigation very little of an experimental nature, giving any tangible suggestion in regard to methods for dealing with functional deficiencies relating to reading disability, had been reported. The experimental work with prism-reading was continued, and numerous excellent suggestions from eye specialists were utilized in perfecting a practical technique that would be

PLATE LXXXI

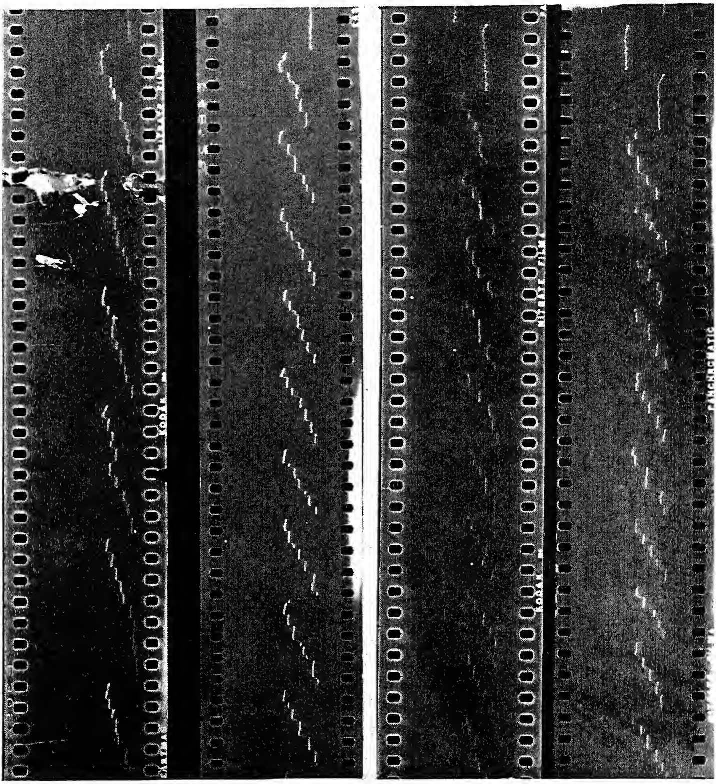


Fig. 63 Fig. 64 Fig. 65 Fig. 66

Monocular Reading-Graphs of Two High-School Students before and after Prism-reading Training

simple in operation. Meantime, a number of publications offering remedial suggestions for dealing with visual defects, based on experimental work, have appeared, and several institutions of higher learning have organized reading clinics and are carrying on corrective work. Eye specialists, as well as educators, have become vitally interested in the problems connected with reading disability, and the new technique, which is described in chapter xii, is now used quite extensively by them in office practice. With suitable instruments now available schools are establishing reading clinics equipped to take care of all types of reading deficiencies, and it is quite obvious that, as techniques and apparatus are further developed, reading disability at the higher levels of instruction will be considerably lessened.

*

CHAPTER XII

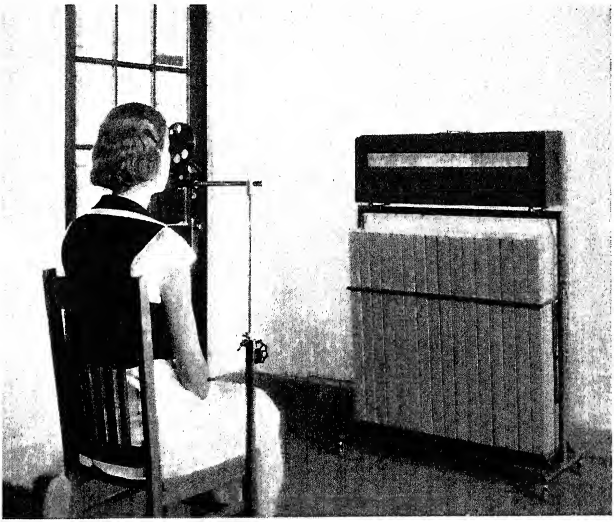
PRISM-READING[1] WITH THE METRON-O-SCOPE

The ultimate purpose of prism-reading, given with the Metron-O-Scope in conjunction with prisms,[2] is to bring about efficient reading, the essential features of which, in addition to comfortable vision, are few fixations, few regressions, rapidity, rhythm, and maximum comprehension. Desirable eye habits are induced by reading exercises which control the eye-movements of children who are learning to read, and by remedial training of this nature for both children and adults who have reading disabilities. It is probable that at least one-half of the students in our public schools and other educational institutions, and of the adult population as well, might benefit from this type of training. Such eye exercises to develop reading efficiency are as essential to the welfare of the student as are other muscle exercises that are part of his work in physical education. Through the use of our eyes we acquire most of our information. It is necessary,

[1] Should be given by, or under the supervision of, an eye specialist.

[2] Cf. pp. 245, 253, and 274.

PLATE LXXXII



PRISM-READING, USING THE GENOTHALMIC REFRACTOR WITH THE SENIOR METRON-O-SCOPE

therefore, that we see as accurately as possible in order to react properly to the information presented, and form associations for its retention. Many eye specialists in this country at the present time are giving and recommending various types of orthoptic training, since they have come to realize that, by the use of prism exercises, it is possible to take care of certain visual anomalies which do not respond to other corrective measures. The problem while mainly within the field of the eye specialist has a definite psychological aspect. The individual (considered as a functional unit) is being reconditioned and rehabilitated to secure comfortable vision, and, since this process involves different patterns of human behavior, any training must be considered, partially at least, from the viewpoint of the psychologist.

Various types of visual inefficiencies respond to this re-educative process with the result that the eyes are reconditioned to function more effectively in binocular fixation. Quite obviously there are some cases of squint in which, before the training begins, an operation to shorten or lengthen one or more of the extrinsic eye-muscles must be performed,[3] but the results of such operations are uncertain in many instances, and practitioners do not now recommend them gen-

[3] Alfred Bielschowsky, M.D., "Lectures on Motor Anomalies of the Eyes, IV. Functional Neuroses: Etiology, Prognosis and Treatment of Ocular Paralysis," *Archives of Ophthalmology*, XIII (May, 1935), 751–70.

erally, except in extreme cases. Operations should be followed by orthontic training so the eyes may be conditioned to work together; otherwise, although apparently straight, they may not be functioning together in binocular fixation, and may later deviate again. This accounts for the fact that at the present time many ophthalmologists recommend prism exercises after most operations for strabismus or squint.[4] In the case of squints of long standing, where the eyes are simply straightened by an operation or by the use of lenses and where reconditioning exercises are not given, it has been proved in some instances, by means of a binocular photograph of the eye-movements during reading, that the eyes are not functioning together. It has been found also that many subjects, with supposedly normal vision, at times suppress[5] the vision of one eye, partially or completely, and usually are not conscious of doing so. Under these circumstances there may be a deviation of the visual axis and consequently a difference in the attention values[6] of the retinal stimulations. If this condition is allowed

[4] Sanford R. Gifford, M.D., *A Handbook of Ocular Therapeutics*, pp. 237–38. Philadelphia: Lea & Ferbiger, 1932.

J. L. Bressler, M.D., "Treatment of Strabismus: Influence of Orthoptic Training on Results of Operation," *Archives of Ophthalmology*, XVI (September, 1936), 433–42.

[5] Table III, p. 167.

[6] Verhoeff, "A New Theory of Binocular Vision," *Archives of Ophthalmology*, XIII, 151–75.

to continue, the visual axis of the eye may deviate more and more until a definite squint develops. Cases of squint or strabismus represent, in many instances, the psychological response of the individual organism to a fusional conflict. This deviation may be called a "compensatory reaction" of the individual organism. This statement that the deviations may be compensatory[7] and therefore functional finds support in the fact that many cases of squint are corrected by prism exercises[8] which would not be possible if an anatomic defect existed.

The technique of prism-reading developed with the Metron-O-Scope is designed not only to take care of binocular imbalances but to condition efficient reading habits, because it is generally in the reading situation that the subject first notices the eye discomfort arising from these defects. Before beginning this remedial training all the subjects should have an eye examination

[7] Jacob B. Feldman, M.D., "The Orthoptic Treatment of Concomitant Squint," *Archives of Ophthalmology*, XIII (March, 1935), 419–34.

[8] George P. Guibor, M.D., "Practical Details in the Orthoptic Treatment of Strabismus," *Archives of Ophthalmology*, XII (December, 1934), 887–98.

Luther C. Peter, M.D., "Technique of Orthoptic Training in Squint," *Archives of Ophthalmology*, XIV (December, 1935), 975–84.

Sheila Mayou, "The Result of Orthoptic Treatment in Divergent Strabismus," *British Journal of Ophthalmology*, XIX (January, 1935), 37–46.

by a competent refractionist, and a binocular photograph of the actual reading performance as recorded by the Ophthalm-O-Graph. The information obtained, and the reading-ratio, determine the type of corrective work to be undertaken. In an effective program it may be necessary to straighten squinting eyes, correct lens power of the glasses worn, or eliminate muscular as well as accommodative insufficiencies.

In giving the exercises prisms are placed before the eyes of the subject, who reads material presented in the Metron-O-Scope. Base-in and base-out training is given to develop binocular co-ordination. With this training it has been found desirable to have the prisms as close as possible to the eyes. If they are not close enough, the deviation of the eye, as in squint, may be so great that no effort is made to react to the light refracted by the prism. It is the desire of the organism to keep this refracted light focused on the macula, which is the stimulus for an attempt to redirect the visual axis as the prism is rotated from time to time. If the prisms are not close enough to the eyes, therefore, there is no incentive to respond when the position is changed by rotation. If the eyes tend to diverge, most of the training takes place with the prisms base-out. If the eyes tend to converge, base-in training is emphasized. In prism-reading over-

stimulation[9] of the eye muscles can be avoided by checking the reading-ratio, in prism diopters, before each practice period. The training begins as soon as it is determined whether the convergence or divergence functions are to receive the greater amount of exercise. During the periods of exercise the prism base is used two or three times as long over the "strong" muscles as over the "weak" ones, and thus no undesirable balance is built up.

It is probable that prism-reading develops excellent co-ordination between convergence and accommodation—factors which are essential for fusion. It aims also to bring about a four-to-one reading-ratio, that is, the divergence reaction, measured in prism diopters, is brought to about one-fourth that of the convergence reaction. This does not imply that everyone has need of a four-to-one reading-ratio, but in training a large number of cases it has been found that this ratio generally results in comfortable vision. A check of a number of these cases a year or two years after training disclosed that many of them had not retained the four-to-one ratio, but the majority had retained enough of the reserve built up for comfort in near-point work.

If there is any indication of amblyopia or sup-

[9] Berens, Losey, and Hardy, "Routine Examinations of the Ocular Muscles and Non-operative Treatment," *American Journal of Ophthalmology*, X, 910–18.

pression of vision, training begins with a prism base-up over one eye and a prism base-down over the other. As long as the eyes remain in the same horizontal plane, the subject will tend to favor the one which gives the best translation of the environmental stimulus. By means of vertical displacement, in which two planes must be considered, the attention value of the stimulus on the deficient retina is enhanced. In other words, in this unusual situation the brain is more likely to recognize that the deficient retina is receiving a stimulus. To induce the deficient eye to resume its normal functions there must be a period of relearning, which, with the Metron-O-Scope, can best be given by the use of vertical displacement.

In a practice period of five to eight minutes the bases of the prisms are alternated several times, so as to prevent the possibility of creating a hyperphoric condition. The prisms are turned from four to twelve prism diopters, base-up and base-down. It has been necessary sometimes, when inducing diplopia in this way, to use a red glass over one eye and a green glass over the other. The color contrast makes the subject aware of two objects where only one was observed before. This procedure is especially desirable with subjects who do not follow directions easily, and in work with very young children. Sometimes it is necessary to occlude the good

eye during the practice period, but usually, if at all possible, the subject is encouraged to use the deficient eye in spite of the fact that the good eye is receiving a stimulus at the same time. If the subject has amblyopia, he is instructed to favor the deficient eye during the training period, and unless there is a defect in the retina the vision improves. In giving the training a very near-sighted subject should be placed four or five feet from the instrument.[10] It may be that he cannot see anything at first except the working of the shutters, but usually the vision improves somewhat as training progresses. Improvement of visual acuity, by means of lenses or eye exercises, or both, is desirable; otherwise there is little hope of getting the best results from binocular training where base-in and base-out prisms are used.

In training some of the subjects in this study plus and minus lenses were used with the base-in and base-out exercises, and also in conjunction with vertically displaced prisms. The assumption was made that this procedure exercised the process of accommodation. Indeed, it was found that training given to some subjects, in this manner, rapidly brought about improved functioning of the visual apparatus. During each

[10] A subject with normal vision is placed 8 to 10 feet from the Senior Metron-O-Scope, but only about 2 feet from the Junior model.

practice period the subject received about five minutes of training while reading through plus or minus lenses, depending upon the nature of the refractive error—the basic idea being to develop approximately the same amount of accommodation in each eye. The lenses were strong enough to necessitate a decided effort on the part of the subject to see, but not strong enough to completely blur out the material presented.

It is known that minus lenses stimulate accommodation, while plus lenses inhibit accommodation. After an eye has been in disuse for a period of time, as in strabismus, it is logical to assume that the accommodative process is probably deficient in its function and that it can be reconditioned to function more normally. A further assumption is that negative stimulation through the use of plus lenses is as necessary as positive stimulation through the use of minus lenses, since the aim is to develop rapid, accurate functioning of the accommodative process.

If the subject has an axial deviation of the eyes, which generally results in amblyopia, it is desirable to use the base-up and base-down prisms in conjunction with plus and minus lenses until a working balance[11] is obtained. A perfect

[11] George Watson, "The Aetiology of Strabismus," *British Journal of Physiological Optics*, X (April, 1936), 12–17.

Avery M. Hicks, M.D., and George N. Hosford, M.D., "Orthoptic Treatment of Squint," *Archives of Ophthalmology*, XIII (June, 1925), 1026–37.

balance would necessarily be one in which the eyes have the same amount of vision and the same amount of accommodation. Naturally, in the majority of cases such a balance cannot be obtained, but the nearer this condition is approached, the more rapid and effective will be the results obtained from any type of base-in and base-out training.

It seems reasonable to suppose that some subjects have less fusional capacity than others, and for this reason there may be great variation in the amount of training required to develop this faculty. In chapter xi it was stated that fusion is probably influenced by convergence, accommodation, and the dominance of one hemisphere of the brain. There are other factors also which seem to have a decided influence upon this psychological phenomenon. For instance, the presence of aniseikonia in varying degrees may be a decided obstacle to the re-establishment of fusion.[12] An interesting case has come under observation in which aniseikonia apparently hindered the re-establishment of fusion. In this case—that of a girl fifteen years old—the right eye had been diverging for about eight years. At the time she came under observation

[12] Alfred Bielschowsky, "Congenital and Acquired Deficiencies of Fusion," *American Journal of Ophthalmology*, XVIII (October, 1935), 925–37.

Wendell L. Hughes, M.D., "Aniseikonia," *American Journal of Ophthalmology*, XIX (August, 1936), 686–88.

she was wearing lenses, but they apparently were not effective in bringing about fusion. A refraction showed that with or without lenses the visual acuity of the right eye was 20/50, while the left eye showed 20/20. When the eyes were vertically displaced by prisms, the subject reported that the ocular image for the right eye was smaller than that for the left eye, although the visual acuity in the right eye was very poor. There was no way to obtain exact information concerning the difference in size of the ocular images because there was no instrument[13] available for measuring it.

In the training vertical displacement was used first, in conjunction with plus and minus lenses, and the visual acuity improved considerably. After a few practice periods base-out exercises were attempted. It was necessary to turn the prisms twelve degrees base-in to establish fusion, but as training continued this was reduced to zero, and base-out training was then possible. At the end of nine weeks the visual acuity in the right eye was 20/30, and the subject could hold thirty prism-diopters base-out, and could also fuse the ocular images while looking at stereoscopic pictures in the Telebinocular. In attempting to maintain fusion, both in near-point and distance vision, the subject was troubled with

[13] This difference can be measured with the Ophthalmo-Eikonometer.

vertical diplopia, which disturbed her a great deal. When diplopia occurred, she could, with an effort, re-establish fusion, but after a short time diplopia recurred. Her training was continued, intermittently, for three months by an eye specialist.[14] During this period 20/20 visual acuity was obtained in the right eye and she was able to hold sixty prism diopters base-out without diplopia, but, as the visual acuity increased, the difference in the size of the ocular images became more noticeable, and the disturbance was greater. It has not been possible to secure a size correction for this subject, and she is experiencing some of the disorders mentioned by Bielschowsky. The findings in this case, the case reported by Bielschowsky, available information from Dartmouth Medical School, and the fact that the majority of squint or strabismus cases are very difficult to deal with by any known orthoptic procedure, suggest that aniseikonia should be considered in all cases of strabismus as one of the possible causative factors.

In using a number of the instruments designed for prism-training it was found that the greater the degree of voluntary interest on the part of the patient the more rapid and effective were the results obtained. After all, there are just two types of training, the type which requires forced

[14] Dr. J. G. Shelton, Austin, Tex.

attention and that which commands involuntary attention. Prism-reading with the Metron-O-Scope commands involuntary attention because the reading material is varied enough to interest subjects of all ages and with varying degrees of reading ability. This training has been carried on successfully with subjects as young as five and as old as sixty years.

If both eyes have approximately the same percentage of vision, it has been found desirable usually to omit base-up and base-down exercises, and to start the training with the prisms base-in and base-out, depending upon the defect present. In vertical displacement it is generally desirable to use number rolls and vocabulary rolls, but in giving the base-in and base-out training this material may be supplemented by stories of all types. The more interesting the material, the greater the concentration of the subject, and this sustained interest is a very important factor in securing desired results. The same general procedure can be followed with young children, by substituting picture rolls for the printed material. Where the subject can recognize numbers, or one-syllable words, however, the number and vocabulary rolls are used with the pictures, as the child enjoys calling the numbers and words which he recognizes as they appear in the windows of the Metron-O-Scope. In prism-reading the practice period—for base-up, base-down,

base-in, or base-out exercises—should not exceed twenty to thirty minutes.

The speed of the instrument is increased from time to time as the training progresses, to induce greater effort on the part of the subject. This procedure conditions greater speed in the adjustments necessary in rapid reading, since the subject learns not only to control the saccadic sweep of the eyes, but also to make the minute adjustments of binocular fixation necessary to clear vision.

Prism-reading in conjunction with the Metron-O-Scope provides effective exercise of the ocular muscles, which conditions comfortable vision and at the same time tends to develop efficient reading habits. When the subject reads through prisms material exposed intermittently in the Metron-O-Scope, an unusual situation is created. The light reflected from the stimulus is deflected by the prisms as it passes to the eyes. The prism power, in turn, is increased or decreased within a range which is broken only when diplopia occurs. The visual mechanism is exercised when the brain attempts to direct the visual receptors toward the stimulus, and at the same time maintain binocular single vision under stress.

Although the eye-movements are involuntary adjustments, which occur when the organism attempts to give attention to the changing posi-

tion of the stimulus, the pattern of the response is the result of learning and therefore can be changed. It is interesting to note that usually after a very brief period of prism-reading training the subjects begin to report a rather pronounced improvement in general visual efficiency. Objects and print are perceived with greater rapidity and accuracy. This is proof that improved fusional ability accompanies the change in the eye pattern brought about by the training.

The decided improvement in general visual efficiency brought about by prism-reading in the cases trained may be explained, in part, by the fact that the combination of the reading activity and eye-muscle exercises in a controlled situation conditions better co-ordination between the six pairs of ocular muscles. This results, in turn, in more precise lateral control as shown in the improved rhythm of the eye pattern. At the same time, the processes of accommodation and convergence are developed and co-ordinated, and rapid, accurate perception is conditioned. This increased functional efficiency results in more effective reading habits and comfortable vision. In some cases where eye discomfort resulted from eye muscular troubles *alone* no lenses were required after training.[15]

[15] Berens, Losey, and Hardy, *op. cit.*, p. 910.

In conjunction with the increased functional efficiency of the visual mechanism, a broader span of recognition develops. Evidence of this improvement (Table XVI) is the decrease in the number of fixations required for reading a given selection. It is observed that, on the basis of 148 words, before training the subjects averaged 139 fixations, and after training 111 fixations. This means that before training they saw on the average 1.06 words per fixation, while after training this had increased to an average of 1.33 words per fixation. Even though this difference of .27 words per fixation is small, it is a substantial gain and would necessarily mean quite a conservation of time and neural energy on a lengthy reading assignment.

The data given in Table XVI were gathered from children and adults in Austin, Texas, where prism-reading was first used. The subjects ranged in age from fourteen to sixty-five years. As a result of the training it was found that some of the older subjects responded quite as rapidly and showed as much improvement in reading as the younger subjects. It should be noted in this connection that the improvement in reading observed in Table XVI came about incidentally in connection with the comfortable vision produced by prism-reading. Most of the subjects in this study were suffering from headaches, eye burn,

and general ocular discomfort, which accompany asthenopia[16] or eyestrain. For this reason it is not known how much the reading could have been improved had the training continued for a longer time, because age did not appear to hinder the improvement of reading habits or the enlargement of the span of recognition.[17] The last column of Table XVI shows that the subjects averaged 13.16 practice periods, or about 4.38 hours of training. These practice periods for each subject usually extended over two or three weeks. Some of the subjects who could not come twice a day, or even once a day, practiced only once or twice a week. Daily practice, of course, was found to produce the most rapid improvement, but the same end result occurred where the subjects could not come so often.

The data are given very little statistical treatment, because each subject is a case study, and the amount of training involved in balancing the interni and externi eye muscles, so that an approximate $10^{\Delta}/40^{\Delta}$ reading-ratio can be obtained, varies from subject to subject. In Table XVI it

[16] Three kinds: (*a*) retinal—intolerance of light or a condition known as "photophobia"; (*b*) muscular—pain resulting from the rapid fatigue of the muscles controlling the movements of the eyes; (*c*) accommodative—pain resulting from undue fatigue of the process by which the light rays are brought to a focus on the macula.

[17] W. H. Pyle, "The Reading Span," *Elementary School Journal*, XXIX (April, 1929), 597–602.

TABLE XVI

Data on Twenty-five Subjects before and after Prism-reading Training*

Subject	Fixations		Regressions		Comprehension		Words Per Min.		No. 20-Min. Practice Periods
	Before	After	Before	After	Before	After	Before	After	
1	113	92	17	3	75.00	75.00	284.79	446.24	13
2	112	93	14	11	100.00	100.00	301.73	405.85	15
3	131	92	12	1	62.50	75.00	212.08	374.24	15
4	184	147	34	21	75.00	87.50	135.84	224.12	14
5	122	123	28	26	75.00	87.50	236.80	264.30	15
6	164	125	45	28	62.50	87.50	211.42	308.37	16
7	216	168	70	44	100.00	87.50	175.42	214.69	17
8	224	156	46	29	87.50	87.50	143.80	217.96	11
9	154	113	19	11	62.50	75.00	202.97	308.86	17
10	126	96	21	15	100.00	87.50	247.22	410.73	12
11	142	113	12	5	75.00	75.00	252.84	347.82	11
12	145	121	30	14	100.00	75.00	208.47	294.08	18
13	124	114	14	19	62.50	87.50	197.33	251.91	12
14	102	67	12	5	75.00	87.50	401.45	622.04	10
15	148	144	39	31	62.50	100.00	210.00	231.89	15
16	144	106	27	11	75.00	75.00	237.36	381.81	14
17	84	63	15	6	75.00	87.50	444.00	649.41	10
18	132	108	13	5	62.50	75.00	213.97	364.00	22

* Data tabulated in each case on 148 words of reading material of the same difficulty

TABLE XVI—*Continued*

Subject	Fixations		Regressions		Comprehension		Words Per Min.		No. 20-Min. Practice Periods
	Before	After	Before	After	Before	After	Before	After	
19	106	105	1	10	100.00	100.00	318.62	335.69	12
20	153	121	35	27	75.00	75.00	243.07	323.07	8
21	128	84	29	10	75.00	100.00	305.61	481.40	15
22	131	119	24	14	50.00	75.00	258.81	334.21	20
23	112	96	5	6	87.50	75.00	338.28	405.66	10
24	143	134	13	8	50.00	75.00	249.22	330.60	10
25	108	66	18	6	100.00	100.00	341.53	596.77	7
Mean	139.00	111.00	24.36	15.32	77.00	84.50	256.20	368.80	13.16
Percentage	Decrease 20.14		Decrease 37.11		Gain 9.74		Gain 43.90		

is observed that as a result of the training the subjects show a decrease of 20.14 per cent of fixations required in reading 148 words. There

TABLE XVII

DATA ON TWENTY-FIVE SUBJECTS—RELIABILITIES OF THE DIFFERENCES SHOWING IMPROVEMENTS WITHIN THE GROUP

NATURE OF DATA	MEANS		DIFFERENCE OF THE MEANS BEFORE + AFTER	σ OF THE DIFFERENCE	RATIO OF DIFFERENCE TO σ OF DIFFERENCE	RELIABILITY OF DIFFERENCE
	Before	After				
1. Fixations.......	139.00	111.00	28.0	8.26	3.39	99
σ............	32.00	26.08	......	......	......	......
Standard error of the mean	6.40	5.22	......	......	......	......
2. Regressions.....	24.36	15.32	9.04	3.50	2.58	99
σ............	14.21	10.24	......	......	......	......
Standard error of the mean	2.84	2.05	......	......	......	......
3. Comprehension.	77.00	84.50	7.50	3.75	2.00	96
σ............	15.70	9.54	......	......	......	......
Standard error of the mean	3.20	1.95	......	......	......	......
4. Words per minute..........	256.20	368.80	112.60	28.07	4.01	99
σ............	73.62	119.48	......	......	......	......
Standard error of the mean	14.72	23.90	......	......	......	......

is a decrease of 37.11 per cent in the number of regressive movements. Comprehension increases 9.74 per cent, in spite of the fact that there is a 43.90 per cent increase in the speed of reading. In Table XVII it is interesting to note that the

standard deviations are all smaller after training except that for speed in words per minute. In this instance there appears to be such a stirring-up within the group that the standard deviation is larger than the difference between the means. With regard to the differences in the number of fixations and regressions, and in the speed and comprehension of the group before and after training, it is seen that they are highly reliable in every instance. The reading-graphs on Plates LXXXIV–XCI depict typical changes which result from prism-reading training. The data presented for each graph are on the basis of one hundred words in order that comparison may be made readily with the Table of Norms[18] which is in terms of one hundred words of reading material for the various grade levels.

It is fairly obvious that these data have significance for both the educator and the eye specialist. By using the technique of prism-reading, in combination with photography of eye-movements, the eye specialist has at his disposal a definite means of getting at difficulties which could not be taken care of before. With this tangible procedure and co-operation on the part of eye specialist and teacher many problem cases that have not responded to other methods may be reconditioned to function more normally in the classroom situation.

[18] Cf. p. 127.

PLATE LXXXIII

Courtesy American Optical Company

PRISM-READING, USING THE PHOROMETER AND THE JUNIOR METRON-O-SCOPE

FIG. 67

FIG. 68

READING-GRAPHS OF HIGH-SCHOOL GIRL AGED FIFTEEN YEARS, BEFORE AND AFTER PRISM-READING TRAINING

She had worn lenses for seven years. Visual acuity was the same with and without lenses. There was noticeable redness of the eyes and she reported eye discomfort and headaches. ℞ = O.U. −0.50 ax 180. Refraction was made under a cycloplegic.

Received twelve 20-minute periods of prism-reading training, three practice periods per week. The subjective symptoms disappeared and no lenses were prescribed.

One year later the subject reported that she still had comfortable vision. The reading-rate was still better than six hundred words per minute.

Test Data	Before Training	After Training
Fixations per 100 words	75	56
Regressions per 100 words	11	6
Speed	473	616
Comprehension	100	100
Visual acuity (both eyes)	20/30	20/20
Reading-ratio	$10^{\Delta}/15^{\Delta}$	$10^{\Delta}/36^{\Delta}$

This girl was valedictorian of her class and is now attending the University of Texas.

PLATE LXXXV

Fig. 69

Fig. 70

Fig. 71

Reading-Graphs of High-School Girl Aged Eighteen Years, before and after Prism-reading Training

No lenses worn either before or after training. Fifteen twenty-minute periods of prism-reading, with emphasis on base-out exercises.

Test Data	Before Training	After Training	One Year Later
Fixations per 100 words	87	57	70
Regressions per 100 words	20	7	8
Speed	305.61	481.40	355.00
Comprehension	75	100	75

PLATE LXXXVI

Fig. 72

Fig. 73

Fig. 74

Reading-Graphs of High-School Boy Aged Eighteen Years

Was doing very poor school work and reported eye discomfort and constant headaches. ℞ = O.U. +0.75 sph.

Twelve 20-minute periods of prism-reading with emphasis on base-out exercises. ℞:

	Sph.	Cyl.	Axis	Visual Acuity
O.D.	....	+0.50	105	20/20
O.S.	....	+0.37	105	20/20

The subject later was graduated from high school and one year after completion of the training period reported that he still had comfortable vision.

Test Data	Before Training	After Training	One Year Later
Fixations per 100 words	85	65	56
Regressions per 100 words	14	10	4
Speed	247.22	410.73	460.54
Comprehension	100	87.50	100
Reading-ratio	10Δ/16Δ	10Δ/40Δ	10Δ/30Δ

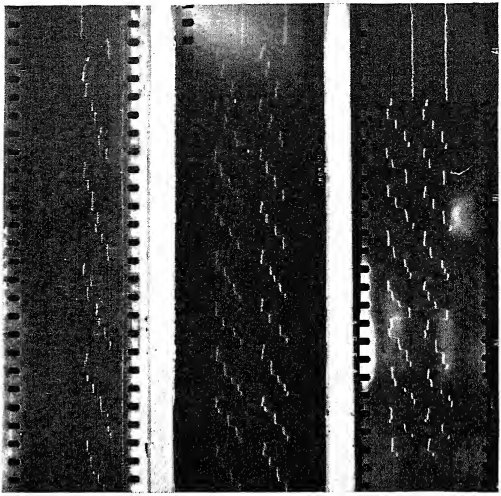


FIG. 75 FIG. 76 FIG. 77

READING-GRAPHS OF YOUNG MAN AGED TWENTY-SEVEN YEARS

Figure 75 was made with the first *portable monocular* eye-movement camera, and the other two graphs with the first *portable binocular* eye-movement camera.

This subject seemed to be a progressive myopic type; lenses had been changed frequently. ℞:

	Sph.	Cyl.	Axis
O.D.	−5.50	....	....
O.S.	−5.00	....	....

This correction carried 4° of prism base-in.

Thirteen twenty-minute periods of prism-reading, with emphasis on base-in exercises; later followed by twenty additional periods in which the subject read through −3.00 lenses to see if his former correction could be reduced. The visual acuity remained approximately the same before and after training. After training, ℞ was changed to:

	Sph.	Cyl.	Axis
O.D.	−4.50	....	....
O.S.	−4.25	....	....

In terms of fixations and regressions the subject was an efficient reader for a college graduate, but in speed he was reading at the high-school level. As a result of the training, the eye habit improved and the speed exceeded the college norm. His general reading ability improved as he continued to practice a more efficient reading habit. Data from Figure 77, taken one year after the preliminary photography, indicate that he is a superior reader.

Test Data	Before Training	After Training	Four Months Later
Fixations per 100 words	76	62	52
Regressions per 100 words	11	3	4
Speed	284.79	446.24	568.00
Comprehension	75	75	100
Reading-ratio	4△/36△	8△/40△	8△/36△

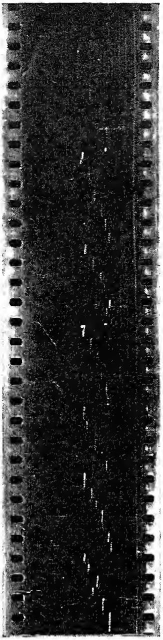


Fig. 78

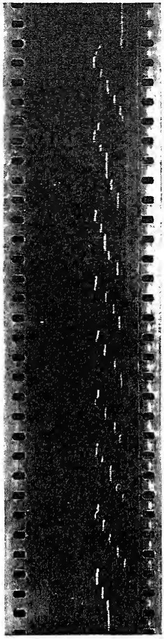


Fig. 79

Fig. 80

Reading-Graphs of Young Man Aged Twenty-eight Years
(Two of the graphs were made with a monocular camera)

℞:

	Sph.	Cyl.	Axis
O.D.	....	+0.50	75
O.S.	....	+0.50	105

Fifteen twenty-minute periods of prism-reading, with emphasis on base-in exercises. ℞:

	Sph.	Cyl.	Axis	Visual Acuity
O.D.	+0.25	+0.50	75	20/20
O.S.	+0.25	+0.50	105	20/20

Test Data	Before Training	After Training	One Year Later
Fixations per 100 words	76	63	67
Regressions per 100 words	9	7	4
Speed	301.73	405.85	448.42
Comprehension	100	100	100
Reading-ratio	$3^{\Delta}/28^{\Delta}$	$11^{\Delta}/44^{\Delta}$	$8^{\Delta}/36^{\Delta}$

PLATE LXXXIX

Fig. 81

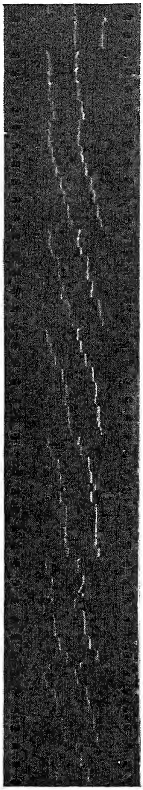


Fig. 82

Fig. 83

Reading-Graphs of High-School Boy Aged Fifteen Years

A pronounced case of anisometropia. He had almost constant headaches but wore no lenses. Eye examination showed need of ℞.

	Sph.	Cyl.	Axis	Visual Acuity
O.D.	+0.62	......	....	20/20
O.S..	+4.00	+1.00	75	20/300

Visual acuity in the left eye was 20/300 with or without lenses.

The subject received only eleven twenty-minute periods of prism-reading, almost all the training involving vertical displacement to build up the vision in the left eye. Unfortunately, training could not be continued. It would require a great deal of time to bring the visual acuity in the two eyes to a state of approximate equality. As long as this difference exists, the subject will suppress the vision of the left eye and the gain in visual acuity due to the prism-reading training will be lost gradually.

After training the following ℞ was given:

	Sph.	Cyl.	Axis	Visual Acuity
O.D.	+0.25	+0.50	90	20/20
O.S..	+4.00	......	....	20/100

The subject had relief from headaches and a year later still had comfortable vision.

Test Data	Before Training	After Training	One Year Later
Fixations per 100 words.....	151	105	105
Regressions per 100 words...	31	19	18
Speed.....................	143.80	217.96	313.22
Comprehension....... ..	87.50	87.50	100

ING-GRAPHS OF HIGH-SCHOOL
RL AGED FIFTEEN YEARS BE-
RE AND AFTER PRISM-READING
AINING

e subject wore no lenses be-
r after training but an eye ex-
ation indicated the need for ℞.

	Sph.	Cyl.	Axis	Visual Acuity
...	+0.50	+0.50	90	20/20
...	+0.50	+0.50	90	20/25

e eye-movements were very
sh. Fourteen twenty-minute
ls of prism-reading, with em-
s on base-out exercises, were
. It is possible that with lenses
greater improvement in read-
bility would have resulted.

Test Data	Before Training	After Training
ons per 100 ds...........	124	99
ssions per 100 ds...........	23	14
....	135.84	224.12
rehension....	75	87.50
ng-ratio......	15△/32△	16△/56△

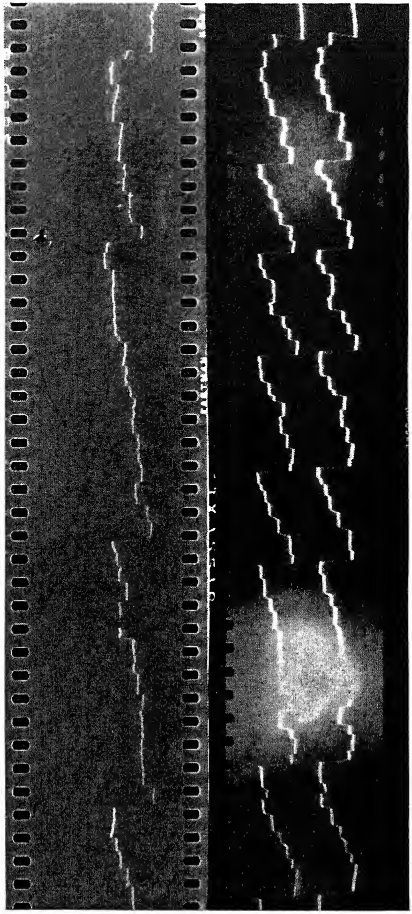


FIG. 84 FIG. 85

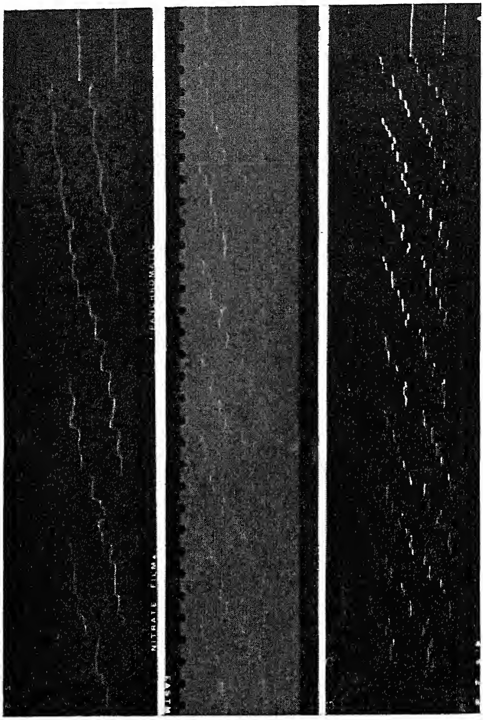


Fig. 86 Fig. 87 Fig. 88

Reading-Graphs of High-School Girl Aged Fifteen Years, before and after Prism-reading Training

This subject was troubled with eye-burn, headaches, and excessive blinking. She was given a refraction under a cycloplegic and supplied with the following ℞, which did not relieve the trouble (O.U.+0.75 sph.). Sixteen twenty-minute periods of prism-reading training, with emphasis on base-out exercises, were given. No lenses were worn after the training, the eye discomfort disappeared, and the student's school work improved.

	Before Training	After Training	One Year Later
Fixations per 100 words	111	85	87
Regressions per 100 words	31	19	14
Speed	211.42	308.37	409.75
Comprehension	62.50	87.50	62.50
Reading-ratio	$12^{\Delta}/20^{\Delta}$	$10^{\Delta}/42^{\Delta}$	$10^{\Delta}/33^{\Delta}$

In developing and applying the technique of prism-reading the following principles and rules were formulated:

1. A definite eye habit, suitable for efficient reading, should be established during the period of exercise. This habit, which is in constant use in near-point work, lends greater assurance that the improvement will be more or less permanent.

2. In giving prism-reading it is desirable that the prisms be as close to the eyes as possible.

3. Vertical displacement should be used in practically all cases of suppression and amblyopia, or with any cases indicating a fusional conflict. The prisms should be turned equally base-up and base-down and alternated from time to time during the practice period so as not to create a hyperphoric condition.

4. Plus and minus lenses may be used in conjunction with the prisms to exercise the process of accommodation.

5. Control of the eye balance should be maintained by checking the reading-ratio before each period of training. In this way proper amounts of base-in and base-out training may be given without overstimulating any of the eye muscles.

6. Excessive amounts of abduction and adduction probably should not be built up because there is no point in training beyond comfortable and efficient vision. Often a reserve of only a few prism diopters permits comfortable vision,

and in most instances, except in cases of squint, 10^{Δ} base-in and 40^{Δ} base-out at ten feet gives sufficient reserve.

7. Cases probably exist that should be given exercises periodically, although a number of subjects have been checked one or two years after training and the results obtained were still in effect.

8. Practically all subjects having defects of the types indicated in this study will respond favorably to the training. Some subjects, however, require a longer period of training before changes in the visual apparatus occur. It is equally true that the reading of nearly all subjects will improve, yet there are a few cases where, although comfortable vision is obtained, there is little improvement in reading ability.

TRENDS AND CONCLUSIONS

The United States Bureau of Education in its biennial survey[1] covers 276,555 schools, of which 259,159 are elementary and secondary schools. The total number included in the school population is more than thirty and a half millions, of which more than twenty-nine millions are in the schools under public control. In the elementary and secondary schools there are approximately nine hundred and fifty thousand teachers, while at the college level about ninety thousand teachers are actively engaged in instruction. The total annual operating cost of the schools in the United States is nearly $3,250,000,000, of which nearly $2,500,000,000 is required for elementary and secondary education. Each year large numbers of students fail, and the schools spend many millions of dollars in reteaching and remedial work. The loss in dollars and cents, however, is not the most important thing in this situation. The discouragement and humiliation of students who continue to fail in their school work, and the disappointment of parents who have sometimes

[1] *Statistical Summary of Education, 1931–1932.* The Preface to the biennial survey of education in the United States, 1930–32. Bulletin, 1935, No. 2. Washington: Government Printing Office, 1934.

sacrificed to give their children an education, are the real elements of the tragedy. As a result of this condition many communities at the present time are taking very definite steps to analyze and evaluate the curriculum in an effort to eliminate inefficient and wasteful procedures.

The school survey has proved to be an effective means for determining the value of various educational practices and in bringing about necessary changes in classroom procedures. In a general school survey the binocular reading-graph obtained with the Ophthalm-O-Graph is an indispensable device in diagnosing reading ability, supplementing any other type of reading test with objective information which can be secured by no other means. With this objective information the teacher at any level of instruction is better able to classify her pupils on the basis of reading ability, differentiating sharply between those who are prepared to carry the normal reading load and those who need special training. Further, in cases of reading disability, the reading-graph suggests the type of corrective procedure to be followed. The controlled reading techniques practiced with the Metron-O-Scope permit adequate correction of many types of reading disability, and, as training proceeds, reading-graphs taken from time to time provide comparable

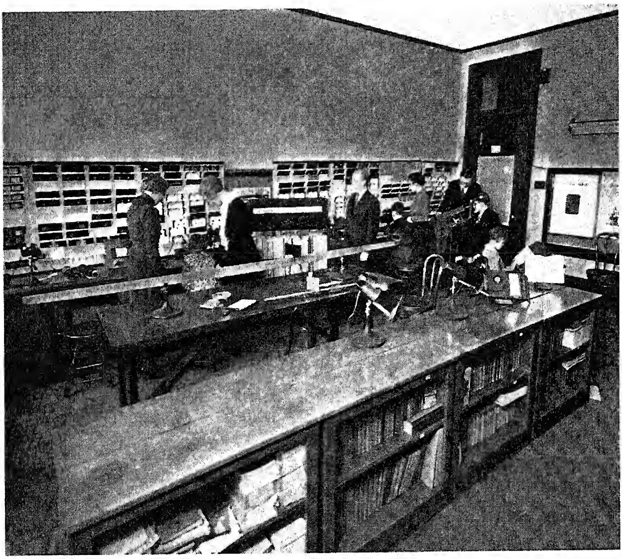
data which enable the teacher to adapt her program to the changing needs of the individual.

By means of eye-movement photography colleges can obtain in advance objective information as to the maturity of the reading habits of incoming Freshmen. This phase of individual diagnosis is already in use in some institutions, and it will be more widely adopted as its value is recognized. The binocular reading-graph indicates the students who are capable of carrying the reading load at the college level, and is both a diagnostic and a prognostic device in cases of reading disability.

In the field of reading a vigorous program is being carried on in a number of educational institutions. Reading clinics in teacher-training institutions acquaint prospective teachers with the latest techniques and apparatus. Courses are conducted in which the student not only becomes familiar with the theories underlying recent developments, but actually takes part in carrying out various techniques and manipulating the apparatus in use in the clinic. The reading clinics conducted by Dr. W. S. Gray at the University of Chicago, Dr. Emmett A. Betts at the State Normal School, Oswego, New York,[2] Dr. Louise Farwell at the National College of Education,[3]

[2] Cf. picture, p. 288. [3] Cf. pp. 289, 290.

PLATE XCII



Courtesy Dr. Emmett A. Betts

READING CLINIC AT THE STATE NORMAL SCHOOL, OSWEGO, NEW YORK—DR. EMMETT A. BETTS, DIRECTOR

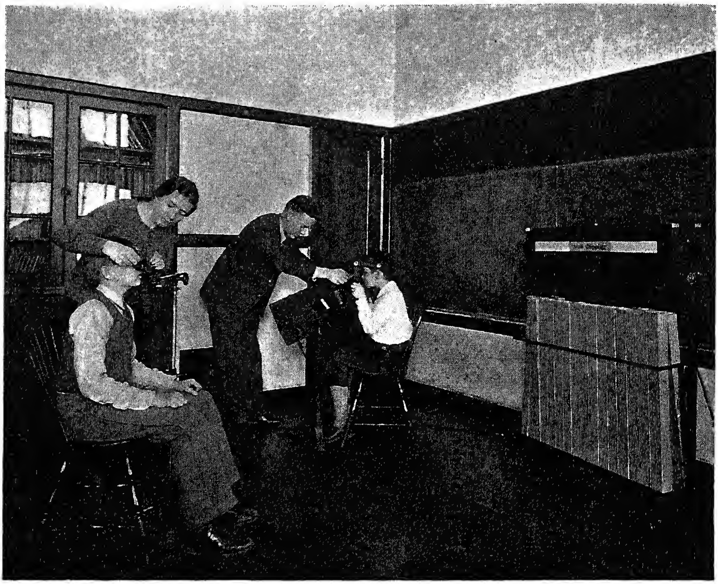
PLATE XCIII

Courtesy National College of Education

An Elementary Class in Corrective Reading in the Reading Clinic Conducted by Dr. Louise Farwell, Director of Research, National College of Education, Evanston, Illinois

This is one of the most modern and complete of the reading clinics in the United States.

PLATE XCIV



Courtesy National College of Education

PRISM-READING AND PHOTOGRAPHY OF EYE-MOVEMENTS IN THE READING CLINIC CONDUCTED BY DR. LOUISE FARWELL, DIRECTOR OF RESEARCH, NATIONAL COLLEGE OF EDUCATION, EVANSTON, ILLINOIS

PLATE XCV

Courtesy Mrs. Hattie Price Baker

TEACHERS IN TRAINING IMPROVE THEIR OWN READING HABITS AND LEARN TO USE MODERN INSTRUMENTATION IN THE CLASSROOM, HOWARD PAYNE COLLEGE, BROWNWOOD, TEXAS—MRS. HATTIE PRICE BAKER, INSTRUCTOR

Evanston, Illinois, Mrs. Hattie Price Baker at Howard Payne College, Brownwood, Texas,[4] and Dr. Stella S. Center and Mrs. Gladys L. Persons at New York University and the Roosevelt High School, New York City, are excellent examples of recent developments. Although corrective measures continue to occupy an important place in the reading program, it is evident that the present trend is toward more elaborate diagnostic procedures, with a view to the prevention of reading disability.

The following case studies, quoted from Dr. Farwell's reports, are an indication of what may be accomplished in individual cases of reading disability at the elementary-school level.

T. B. is a sturdy, dark-haired boy of eleven, with considerable physical stamina. He has not had any serious illnesses, but many severe colds and hay-fever have affected his school attendance somewhat.

He has been given the Binet-Simon test of intelligence three times and made the following scores, according to the Durrell scoring: 116, 105, 112. The average of 111 is a rather high intelligence rating.

As far as personal traits are concerned, he coöperates well in a school situation, is friendly and well liked by both teachers and classmates, has a happy disposition and a sense of humor, strives to work hard, and seems to be ambitious.

When T. B. was seven years of age there was little evi-

[4] Cf. picture, p. 291.

dence of learning in reading or spelling; both subjects have been very difficult for him. The gains in these subjects, as shown in the following table, were measured by the standardized tests known as the New Stanford Achievement Test and the Metropolitan Achievement Tests.

Grade	Date of Tests	Reading		Spelling	Reading Indexes*
		Silent	Oral		
1........	5–22–32	1.4	0.0	....	....
2........	5–15–33	2.2	1.6	1.9	68
3........	5–24–34	3.4	2.9	2.6	77
4........	5–20–35	4.4	4.5	3.1	85
5........	3–30–36	3.8	5.2	3.8	....

* Monroe, *Children Who Cannot Read*, pp. 14–15, 191.

In nearly four years T. B. has gained about three and a half years in silent reading, five years in oral reading, and almost four years in spelling. There has been a definite increase in the reading index.

The high spots in the diagnosis are: He is right-handed and right-footed in both preference and skill; but has preferred the left eye until recently. He is a fluent mirror-reader and an excellent mirror-writer. There has been confusion in directional movement with little memory for words and inability to retain instruction in phonetics, especially with vowel sounds.

The eye-specialist reports: "Muscle imbalance and fusion are good; he has a moderate hyperopic astigmatism and sees 20/20 in each eye when this is corrected (20/25 without correction)."

When T. B. read in May, 1935, first with one eye, then with the other, and then with both eyes, using either a Tachistoscope or the Gray Oral Reading Check Tests, we found that the left eye excelled both the right eye and both eyes in oral reading.

As far as training is concerned, we have had T. B. create some of his own reading content, and have allowed him to select, within some limitations, many of the books which he has read. The phonetic approach in attacking new and difficult words has been emphasized, especially through the kinaesthetic method of writing the word quickly while simultaneously saying it in natural sound units. An attempt has been made to control the left-to-right movement of the eyes, and, until the last year, more oral than silent reading has been given. The Metron-O-Scope was used in the spring of 1935 and at least three times a week during the current school year, although T. B. was only one of a group.

The data from the reading-graph taken with the Ophthalm-O-Graph indicates greater gains than do the results of the standardized tests.

Date	Rate: Words Read per Minute	Number of Fixations	Number of Regressions
4–1–35.......	97 (norm 168)	160 (norm 140)	24 (norm 30)
6–26–35......	158 (norm 198)	106 (norm 115)	11 (norm 25)

The use of rotary prisms has just been started and we are anticipating greater gains in the future because a method of scientific therapy adapted to this type of case is now available with the combined use of the prisms and the Metron-O-Scope.

Table XVIII presents data on four cases of dyslexia. Case No. 2, a boy eleven years and eight months old, is at the end of the sixth grade. He is an allergic type, and has constant difficulty in breathing. The present plan is for him to remain in sixth grade another year.

His corrected mental age at this time is 12.11, but the educational age from the results of standardized tests given the first week of April is only 11.1.

He has always had difficulty in motor control; is left-handed and left-footed in both preference and skill, and has preferred the right eye until recently, when there seems

TABLE XVIII

DATA ON FOUR DYSLEXIA* CASES BEFORE AND AFTER TRAINING WITH THE METRON-O-SCOPE†

Cases	Grade Rating of Material Used		Nature o Data	Before Training	After Training	Norms by Grades
	4-1-35	6-20-35				
1. Boy. Grade 6. Reading index 60	4	4	Fixations.....	148	126	140–115
			Regressions...	32	21	30–25
			R. rate: words per minute.....	125	130	168–198
2. Boy. Grade 5. Reading index 73	4	5	Fixations.....	180	82	140–100
			Regressions...	60	3	30–20
			R. rate: words per minute.....	81	247	168–225
3. Boy. Grade 5. Reading index 78	4	5	Fixations.....	188	76	140–100
			Regressions...	44	11	30–20
			R. rate: words per minute.....	97	218	168–225
4. Boy. Grade 4. Reading index 81	3	4	Fixations.....	120	95	175–115
			Regressions...	32	15	40–25
			R. rate: words per minute.....	200	143	115–198

* Inability to read.
† Practice periods of one-half hour a day three times a week for about ten weeks.

to have been a shift to the left. His hand-writing has improved slightly, but many of his teachers believe that he should learn to typewrite.

There have been emotional difficulties in the home, partially the result of the all too apparent disappointment of the father in his son's academic accomplishments.

The gains since January 1, 1933, are as follows:

Dates	Reading		Spelling	Arithmetic		Eng.	Hist.	Geog.	Total
	Silent	Oral		Comp.	Reas.				
1–25–33	1.9	0.0	1.7	2.4	.....	.....	.....	.....	2.4
5–15–33	2.3	1.6	2.1	2.5	2.3	.....	.....	.....	3.2
5–21–34	3.6	3.6	2.8	4.0	3.7	4.3	3.7	4.0	3.8
5–25–35	4.4	4.4	3.3	4.5	4.0	4.5	4.7	4.3	4.2
3–30–36	5.6	.....	3.9	5.2	5.2	6.5	5.4	5.2	5.5

The eye-specialist in this case reports normal vision and only a moderate refractive error. When reading with each eye separately, and with the two eyes together, from either the Tachistoscope or the Gray Oral Reading Check Tests, we found in May, 1935, that the right eye had the best record.

The gains during the last year, while he has been receiving training with the Metron-O-Scope are greater than at any other time.

This boy is now receiving prism-reading training with the Metron-O-Scope almost daily.

Dr. Farwell uses the following outlines in controlled-reading classes with the Metron-O-Scope. The student-teachers not only learn to read more effectively themselves by this training, but they learn to manipulate the apparatus and apply the techniques.

I. *Positive Suggestions for Children:*

1. Sit directly in front of the instrument, if possible and eight to ten feet from it. Twenty feet is not too far away if your vision is normal.
2. Make yourself comfortable; keep your body relaxed and quiet.
3. Give your eyes a chance to get into correct habits of reading, with a rhythmical left-to-right movement.
4. Read the material shutter by shutter. If you get lost, omit a few shutters, and then catch up with the instrument.
5. When reading orally, say the words quickly and keep the voice low.
6. To improve your reading:
   a) Work kinaesthetically on the words which are difficult for you. Record each word on a card for your card-catalogue, after looking up the meaning and pronunciation and using it in a sentence. Learn these words, so that you will know them when the roll is presented again.
   b) Ask questions when the meaning of the content is not clear.
   c) Help the teacher record your percentage of accuracy and the number of lines read per minute. Be ambitious to improve your record daily.

II. *Positive Suggestions for the Teacher:*

1. Secure a reading-graph for each subject before training begins.
2. Have available the records of latest oral and silent reading scores for each child. Spelling scores also are indicative of the type of difficulty in the individual case.
3. Select the roll according to the grade level of the individual or group with which you are working.

Do not repeat a roll too often, for memory is bound to affect results in terms of percentage of accuracy. [Dr. Farwell has devised a very effective way of checking accuracy.]

4. Have each individual read orally. If the accuracy of reading the material from forty or more shutters is 85 per cent or over, the instrument can be increased in speed.
5. In the case of poor readers:
   a) Read orally while the child reads silently. Set the instrument at a lower speed.
   b) Use a pointer to further aid word recognition. Stop the Metron-O-Scope frequently if necessary.
   c) Work on many of the words kinaesthetically. Put them on individual cards for drill purposes. Give phonetic help.
   d) Concert reading of instructor and child is often helpful.
   e) Let the child aid in the creating of content for a new roll.
6. Group reading:
   a) Let each child have an opportunity to read at least once a day.
   b) Record the name of the child, the roll used, the date, speed of reading and percentage of accuracy.
   c) Make a straight line for each shutter read accurately and a cross for each one containing an error or errors. Record as many of these as possible. Let the group help you to remember, so that the individual child will know what his standing is. At least forty shutters should be read if percentage of accuracy is to be figured from the data.

   d) Set the instrument at a suitable speed for each child. Have his past speed record before you.
   e) Be sure that each child keeps his card-catalogue up to date. Check him constantly on the pronunciation and meanings of words.
   f) When not recording, watch the position of each child and compliment those who maintain good posture.
7. New rolls: Use the same technique as when introducing a new story from a book.
   a) Read a portion aloud to the children and let them originate possible endings.
   b) Read aloud only the more difficult words as the children read the roll silently.
   c) Study the new words, look them up in the dictionary, and so on.
   d) If the roll is informational, question the children about the subject matter. Use pictures to create interest. After reading the material, have the children question each other about the content. Let them list points learned from the reading. Ask them to read additional material in the library on the same subject.
8. From time to time check progress with standardized tests and eye-movement photographs.

Mrs. Leta S. Taylor, who conducted a reading clinic at Educational Laboratories, Inc., Brownwood, Texas, reported the following case of a boy who attended the clinic in 1933:

Case History and Diagnosis: This boy entered school when he was six years old. Although he seemed alert and eager to learn, he made practically no progress in reading during his first school year. Physical and optical examinations

show no pathological or visual anomalies. His mental age was found to be nine years. The reversal tendency was very pronounced, and he was classed as a mirror-reader. He failed at the end of his first school year, and made no progress in a special remedial class where he was placed for five weeks during the following summer. In the fall of 1933 he entered the reading clinic. He could recognize only a few words of one syllable.

An attempt was made to photograph his eye-movements while reading, but the reading-graph was practically a straight line, indicating very little eye-movement. He had no conception, apparently, of how to use his eyes in reading. Under these circumstances, comprehension could not be checked.

Procedure: During the first part of the training period simple pictures of familiar objects were presented in the middle window of the Metron-O-Scope, with the instrument running at its slowest speed. The subject barely recognized the objects in the pictures quickly enough to name them orally as the roll turned. His interest was stimulated, however, and progress was rapid. He was soon able to read with two shutters in operation, but when the material was presented in all three shutters, it was difficult at first for him to follow it in sequence.

After considerable practice, he was able to recognize and name the objects in the pictures at the rate of fifty objects per minute. In all, three picture rolls, consisting of approximately 300 presentations were used during this period of the training.

Word-picture-word material was next presented in the Metron-O-Scope. Two rolls of this material were used, one consisting of the names of objects and the other of action-words. A simple word, such as "boy" was shown in the first window, a picture of a boy appeared in the second

window, and the word was repeated in the third window. On the other roll a familiar action-word, such as "running," "jumping," was shown in the first window, the action was portrayed by an appropriate picture in the second window, and the word was repeated in the third window. The subject was allowed to go over this material a few times, naming the words with the assistance of the pictures, then the center shutter was closed and he was encouraged to recognize the printed words. These words were used also in motivating games as seat work.

As the subject became more skilful in recognizing words, vocabulary rolls were used. Simple stories were then presented, and number rolls were used to give variety and stimulate rapid response. Simple stories, dealing with everyday experiences or associated with the stories presented on the Metron-O-Scope, were used for supplementary practice in both silent and oral reading.

Results: At the end of sixty practice periods, each of which included twenty minutes of reading from the Metron-O-Scope, the subject was found to have low-second grade reading ability. His reading-graph at this time showed a decided improvement, indicating that he had learned to direct his eyes across the lines of print. He returned to school and at the end of his second school year was promoted to low-third grade. He is now in the fourth grade, and his report card shows A's and B's in all subjects. He has had no further difficulty with reading.

The results obtained in these cases support the belief that pupils who have not acquired the mechanical habits which are essential in effective reading, and those who show a tendency to reversal or mirror-reading, respond readily to the methods which are successful with other chil-

dren, if the procedure is varied to meet their individual needs.

The work conducted by Mrs. Hattie Price Baker[4a] in her teacher-training courses is somewhat similar to that just reported. Using children from the various grades, Mrs. Baker demonstrates her procedure with the Metron-O-Scope, and the student-teachers then carry on the actual teaching under her supervision. They themselves also spend part of each class period in learning how to read more effectively.

In addition to carrying on remedial reading work the Metron-O-Scope is used in various ways to motivate student activity at the high-school level. For example, Mr. A. Edward Lamb, former instructor in mathematics and civics in the high school at Smithville, Texas, carried on experimental work for two years, using the Metron-O-Scope for instruction in civics.[5] Two classes in civics took part in the experiment, one designated as the "experimental group" and the other as the "control group." At the beginning of the semester, when the two classes were formed, a reading-graph was secured for each student and he was given a standardized reading test. During the semester progress was checked by numerous short tests on subject matter. At the end of the semester reading-graphs were secured again, and another form of the standardized test was

[4a] Cf. pp. 291, 292.

[5] Cf. picture, p. 303.

PLATE XCVI

Courtesy A. Edward Lamb

HIGH-SCHOOL CLASS IN CIVICS READING FROM THE METRON-O-SCOPE, SMITHVILLE, TEXAS—A. EDWARD LAMB, INSTRUCTOR

used. The grades of each group in all the school subjects, as well as in civics, were compared. The following outline is quoted from Mr. Lamb's reports of the procedure in both classes:

1. *Experimental Group*

In the experimental group materials of both direct and indirect content were presented on the Metron-O-Scope in roll form and used to supplement the adopted textbook. These rolls were divided into units, and were presented as drill, test, and reading rolls. The Metron-O-Scope was used from 15 to 20 minutes daily at the end of the class period, since the beginning of the period was given over to other class activities, such as reports, and discussion of the assignment to be presented on the Metron-O-Scope.

For the first two or three weeks of the school term only light reading material and vocabulary rolls were used in order to accustom the eyes to rhythmical reading at a distance. Later, drill rolls covering the various phases of civics were given, followed by test rolls on this material. All types of objective tests except matching were given on the Metron-O-Scope. An accurate record of time given to each type of test was kept for comparison with those given the control group. The time involved was from 6 to 8 minutes for taking and checking of daily and monthly tests respectively. The mid-term and final tests involved from 40 to 50 minutes.

2. *Control Group*

The same material used in the experimental group was presented in mimeographed form to the control group. Regular class procedure with reports, activities, and so on, was followed, using the mimeographed material to supplement the test.

Oral and written drills on the material from the mimeo-

graphed sheets were given before tests to correspond with the drill rolls on the Metron-O-Scope. These tests were identical with those given in the experimental group and involved from 12 to 35 minutes for daily and monthly tests respectively, and an hour to an hour and forty minutes for the mid-term and final tests.

Conclusions

Teaching with the Metron-O-Scope has proved to be superior to other methods of teaching civics for the following reasons:

1. The subject of civics is more attractive to the student.
2. Concentration is improved: the complete attention of the pupil is gained when the first shutter opens and is held throughout the selection.
3. Material is presented in compact form, therefore easily grasped; non-essentials are eliminated.
4. Advantageous in giving tests—
   a) Saves time for both teacher and pupil; gives more time for supervised study and student activity.
   b) All the pupils complete the test at the same time; when the roll ends all the test papers are completed.
   c) Tends to make thinking more rapid and exact; answers must be put on paper as questions pass on the Metron-O-Scope.
5. Civics is readily correlated with other subjects.
6. Reading efficiency is increased while civics is being taught. The reading-graphs of the subjects in the experimental group show that they are superior to those in the control group in terms of fixations, regressions, speed and comprehension.
7. All the data, including the grades of the subjects in both groups, indicate that the subjects in the experimental group have a better average than those in the control group not only in civics but in the other school subjects.

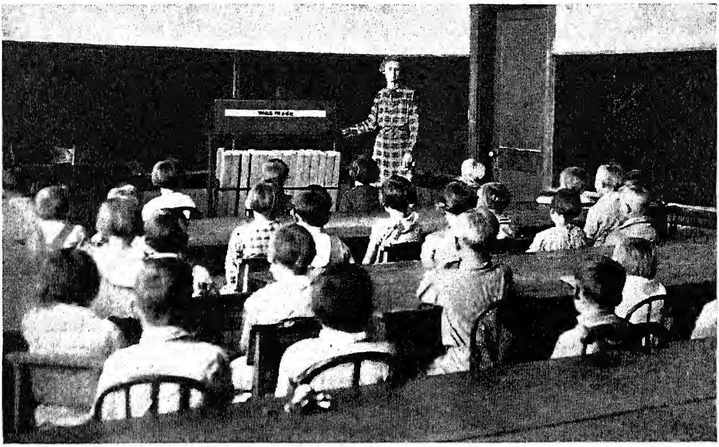
Superintendent P. J. Dodson and his teachers furnished the following outlines of procedure followed in the first six grades of the elementary school at Bastrop, Texas.

Grade 1[6]*—37 pupils*

1. The pupils are not grouped according to ability.
2. The Metron-O-Scope is used daily, during the entire reading period. Twenty minutes is devoted to vocabulary and number drill, and twenty minutes to reading stories. At the beginning of the year all the time was devoted to oral reading, but now (at the end of eight months) this has been decreased to about 75 per cent.
3. One or more pupils read at a time. The class sometimes reads a story together. The slower readers learn a great many words by hearing the other pupils pronounce them.
4. There are many ways to utilize the triple-exposure feature in reading and number work. Sometimes, after a story has been read, we close the first and third windows and the children call the words or phrases shown in the second window. Sometimes we use two windows, and the children fill in the word or words behind the third shutter. We use the word rolls for (*a*) language drill, the pupil who is reciting pronounces the word as it is shown and uses it in an oral sentence, and (*b*) spelling, the pupil looks at the word, then turns away and spells it orally or writes it on the board while the class watches the window to check the spelling. We use the number rolls with one shutter closed, the pupils reading the exposed material and supplying the part that is not shown.

[6] Cf. picture, p. 307.

PLATE XCVII



Courtesy P. J. Dodson

First-Grade Reading Class in the Elementary School, Bastrop, Texas
P. J. Dodson, Superintendent; Mrs. Wilma Arbuckle,
Classroom Teacher

The story rolls are used more than any other type of material. Sand-tables, free-hand drawing, building with blocks, and dramatization are all used to supplement the reading from the Metron-O-Scope. A new story is generally used for dramatization. It is presented once and the children then act it. Even the poorest reader will make sufficient effort to get the thought if the story is to be played.

"I feel I can do more teaching in the forty minutes I have the Metron-O-Scope than in more than double the time without it."[7]

Grade 2—42 pupils

1. I am in favor of grouping, but this cannot be done if they must remain in the same room and under the same teacher.
2. The Metron-O-Scope is used daily. The length of the practice period depends on the type of lesson. Twenty minutes is sufficient for drill in vocabulary or phonics, but in language work, or reading, I take thirty minutes, or even longer, depending in part on the length of the roll and the nature of the material used. About 25 per cent of the class period is devoted to silent reading, and almost all the silent reading is done from the Metron-O-Scope.
3. Sometimes we call on a good reader to read the story aloud to the class as it is presented.
4. In the primary grades this term we are concentrating on reading and the subjects that will be conducive to good reading—language, phrase study, phonics and spelling. Usually a new story is preceded by the vocabulary drill which is part of the material on the roll. Sometimes we take a new word as it appears, and select

[7] This report was furnished by Mrs. Wilma Arbuckle, first-grade teacher.

a phonogram and then think of all the words we know which are built on it. This has proved helpful in enlarging the vocabulary. Sometimes the roll is presented without comment from teacher or class, and the ability of the pupils to find the new words is tested by means of oral questions, or a written lesson, in which tests of the true-false, completion, or multiple-answer type are used. In word study and reading all the shutters are used and the speed is gradually increased. In phrase study the shutters are locked open and the continuous line of print exposed, so that we may identify phrases or word groups. I consider the instrument very valuable for number work also.[8]

Grade 3—34 pupils

1. The pupils are not grouped according to ability.
2. The Metron-O-Scope is used daily, at the beginning of the reading period. The length of the practice period depends on the type of material presented—usually fifteen to thirty minutes.
3. A new roll is presented first as a silent reading exercise. Comprehension is checked by oral stories, written tests, or a count of the new words remembered. Vocabulary and number rolls, and stories for the first, second and third grades are used. The material in the stories is used as a foundation for discussion of geographical facts, racial characteristics and environmental conditions in various parts of the world. The child is encouraged to write and talk freely, and story-telling ability is developed.

As supplementary work, the pupils compile notebooks, arranged in three sections: reading, spelling, and number activities.

This training makes for a highly motivated class

[8] This report was furnished by Mrs. Belle Moore Jones, second-grade teacher.

exercise and furnishes the teacher with an effective method for presenting new material each day.[9]

Grade 4—32 pupils

1. The pupils are not grouped according to ability. Special remedial work is done in obvious cases of non-comprehension or retardation.
2. The Metron-O-Scope is used daily, at the beginning of the reading period, from fifteen to twenty minutes.
3. Most of the work with the instrument is silent reading. About 40 per cent of the book reading is oral.
4. In reading stories and in vocabulary drill the shutters are all used. Vocabulary drill consists of the study of root words, derivations, and accents, and practice in clear pronunciation. In arithmetic the material includes the four fundamental processes and the study of fractional parts. The arithmetic material is first presented with the third shutter closed, and after the pupils have written the answers to the questions, the third window is opened and their work is checked.

   Supplementary work consists of the study of phonics and diacritical markings in connection with the vocabulary rolls; the location on maps of places mentioned in the stories; study of the habits of the animals pictured in the stories; illustration of the stories by pictures.[10]

Grade 5—30 pupils

1. The pupils are not grouped according to ability.
2. Three thirty-minute periods each week are devoted to reading from the Metron-O-Scope. The instrument is

[9] This report was furnished by Miss Annette Booth, third-grade teacher.

[10] This report was furnished by Mrs. Ruby Pearcy, fourth-grade teacher.

used at the beginning of the reading period, and the time is about equally divided between oral and silent reading.

3. The material used is about the same as that listed for Grade 4. The instrument provides a rich field for correlation. Spelling assignments are taken from the vocabulary rolls. In history and geography we locate the places mentioned in the stories and discuss climate and products, and the customs and occupations of the people.[11]

Grade 6—39 pupils

1. The pupils are not grouped according to ability. Very slow readers are drilled orally until they become familiar with the words and increase their rate.
2. The Metron-O-Scope is used at the beginning of each period. The length of the period depends on the type of material presented.
3. The stories are always read first as a silent reading exercise, and about two-thirds of the reading period is devoted to silent reading. The aim is to develop independent habits of study. Vocabulary rolls are used, and comprehension is checked by true-false, completion and multiple-answer tests.

   As supplementary work a vocabulary notebook is compiled by each pupil. Words are spelled, defined, and used in a sentence. Original stories are written, sometimes using the titles of stories presented on the instrument.[12]

Figures 89 and 90 are the reading-graphs of two first-grade students from a class which re-

[11] This report was furnished by Mrs. Corinne Powell, fifth-grade teacher.

[12] This report was furnished by Miss Bernice Hassler, sixth-grade teacher.

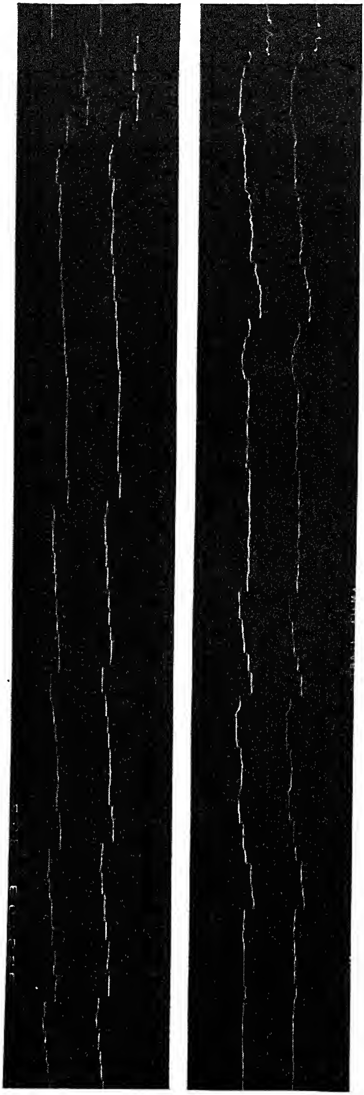


FIG. 89 FIG. 90

READING-GRAPHS OF TWO FIRST-GRADE PUPILS

From a class in which controlled reading was used in the initial teaching of reading. A careful comparison with Plate C reveals that these pupils have a definite eye habit, which was not acquired by the pupils who were taught to read by traditional methods [see Pl. XCIX].

ceived training in reading on the Metron-O-Scope. Figures 91 and 92 are graphs from a group which did not have this training. Obviously first-grade students do not have very fluent reading habits. Comparison of the graphs, however, reveals that the students trained with the Metron-O-Scope have a more definite method of attacking print than those in the other class. There is a more or less decided break for each fixation, and there are fewer fixations and regressions. It is noted that the return sweeps are quite short. This condition probably results from the fact that the reading material used in the photography is composed of very short sentences. Comparison of the comprehension scores of a large number of students from each group shows that, in reading the same material, those with training in controlled reading scored higher on comprehension than those in the other group.

The effects of training with the Metron-O-Scope are further illustrated in the reading-graphs of an eight-year-old boy, shown on Plate C. This pupil was a member of the third-grade class in the Bastrop elementary school, and received the daily training described by Miss Booth[13] during the school year.

For a long time educators have realized that controlled reading is desirable. It is obvious that the number of pupils in the class, individual

[13] Cf. p. 310.

Fig. 91

Fig. 92

Reading-Graphs of Two First-Grade Pupils

These pupils received initial reading instruction by traditional methods.

PLATE C

Reading-Graphs of Eight-Year-Old Boy Who Was in Third Grade

He received training on the Metron-O-Scope for nine months. Figure 93 indicates that he read laboriously and had difficulty in keeping the place on the page. In making the return sweep he was not sure that he could find the beginning of the new line, so he retraced the line just read, then dropped down to the beginning of the new line. Figure 94, taken at the end of the school year, shows that this difficulty has been overcome. The return sweep is normal and the number of fixations and regressions has decreased in a remarkable degree. Before training, the subject read with approximately 182 fixations and 52 regressions per 100 words, at a speed of 88 words per minute. After training he made 132 fixations and 38 regressions while reading at a speed of 171 words per minute.

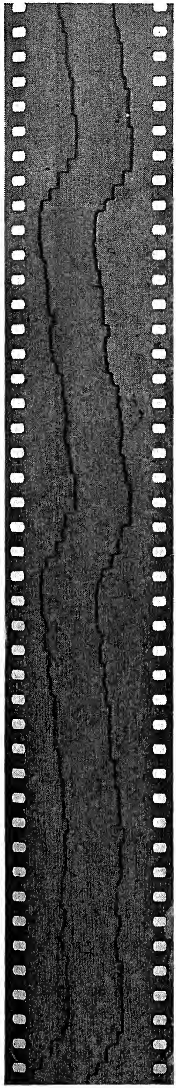


Fig. 93

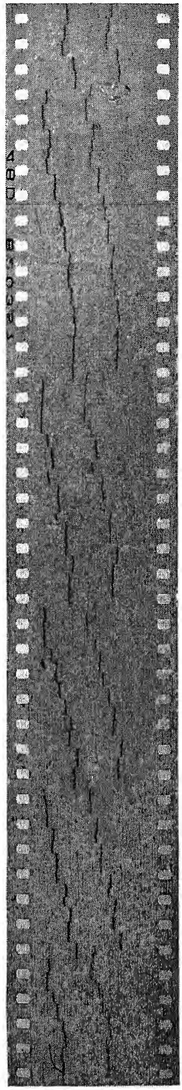


Fig. 94

variability, physical conditions in the classroom, and the training and adaptability of the teacher will all work together to influence the procedures followed at any level of instruction. These outlines, however, and the evidence presented in the reading-graphs, indicate that the techniques developed with the Metron-O-Scope can be used effectively to co-ordinate eye activity and condition rhythmical, left-to-right eye-movements, and, as comprehension is checked, this process is not merely a pacing of eye-movements. It is evident from the reports that the interest factor also is taken care of, and that the instrument furnishes a highly motivated method of reading instruction which makes possible a more direct control of the classroom situation than did techniques employed in the past.

Since the appearance of the *Twenty-fourth Yearbook of the National Society for the Study of Education*,[14] which was devoted to reading, educators have become more fully aware of the necessity for controlled reading training at all levels of instruction. It is recognized that much of the so-called remedial reading consists of merely conditioning the pupils to make adjustments which they should have learned to make during the initial stage. The extensive reading programs

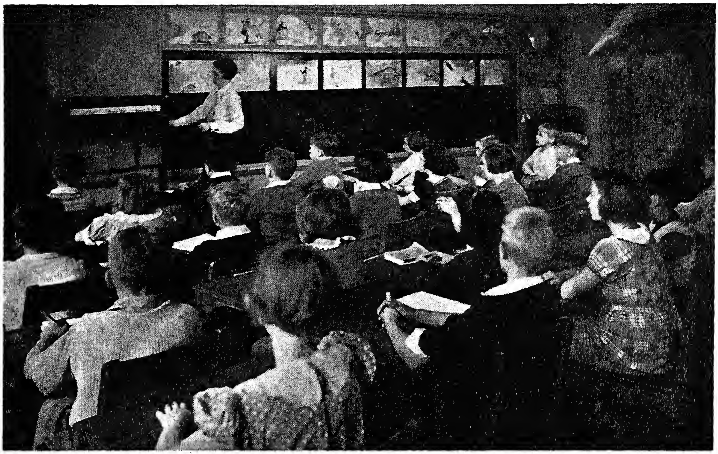
[14] National Committee on Reading, *Twenty-fourth Yearbook of the National Society for the Study of Education*, Part I. Bloomington, Ill.: Public School Publishing Co., 1925. Pp. x+335.

which have developed in our educational institutions in the effort to teach all the children of all the people at higher levels of instruction have revealed the weakness of teaching techniques which do not provide for the *simultaneous development of the mechanical and the interpretative reading processes.* As this book goes to press, there is tangible evidence of a national conviction that many of the problems involved in the teaching of reading can be solved, and that the most economical and satisfactory place to begin is in the pre-reading and initial reading stages of instruction. On the other hand, the prevalence of reading disability at higher grade levels demands equal emphasis within the next few years on corrective measures which provide for definite reading instruction in the upper grades, the high school, and even in the college. With a clear recognition of the problem as it now exists, and with tangible methods of procedure outlined, progressive schools are preparing to carry on a vigorous reading program.[15]

In conjunction with the discussion of reading problems among the school population the question is often asked: "What is the reading efficiency of adults in general?" Table XIX is based on data gathered from 231 clerical workers in a large office. The eye-movements of each subject were photographed with the Ophthalm-O-Graph

[15] Cf. picture, p. 318.

PLATE CI



Courtesy Dr. Carleton W. Washburne

A Fourth-Grade Reading Class in the Greeley School, Winnetka, Illinois—Dr. William H. Voas, Psychologist; Mrs. Fanny Lane, Classroom Teacher

while reading a simple selection from the camera cards for adults, which are part of the equipment furnished with the instrument. The subjects were classified according to occupation, so that the reading efficiency of the different classes could be compared. It was found that 101 of the subjects wore lenses. In terms of fixations the range of the group as a whole was from 64 to 200 per hundred words. In terms of regressions the range was from 4 to 79 per hundred words. The range in speed was from 115 to 480 words per minute. The averages of the entire group in terms of the items listed are: fixations, 106.9 per hundred words; regressions, 20.4 per hundred words; reading-rate, 242.0 words per minute. In Table XIX it is seen that the stenographers and typists are the most rapid readers in this group of clerical workers, but as far as mechanical skill is concerned there is little difference between the subjects in the different divisions.

Teachers engaged in reading research are putting forth a vigorous effort, not only to properly diagnose and correct existing difficulties, but to study the underlying physiological and psychological factors which contribute to school failure. In other words, an effort is being made not only to perfect diagnostic tests, but to understand the processes which are to be tested.[16] Numerous

[16] Raymond Dodge, *Conditions and Consequences of Human Variability*, p. 37. New Haven: Yale University Press, 1931.

new techniques and apparatus make this work possible, and the classroom teacher, as well as the college teacher, is taking advantage of every opportunity to become better acquainted with the latest developments. School authorities are be-

TABLE XIX

DATA FROM THE EYE-MOVEMENT PHOTOGRAPHS OF 231 CLERICAL WORKERS

Nature of Data	Auditors, Book-keepers, etc.	Stenographers, Typists, etc.	Executives, Department Heads, etc.	Clerks
Number of subjects	41	75	11	104
Fixations	109.76	108.00	115.91	108.56
σ	21.70	21.66	15.13	21.83
Standard error of the mean	3.39	2.50	4.56	2.14
Regressions	22.56	20.20	25.45	20.72
σ	12.05	11.12	8.79	10.49
Standard error of the mean	1.88	1.28	2.65	1.03
Words per minute	236.28	252.17	232.55	240.63
σ	58.43	58.61	39.92	65.11
Standard error of the mean	9.13	6.77	12.02	6.38

ing brought to realize that the teacher, in order to carry on a comprehensive teaching and remedial program, must be supplied with proper materials for such work. Many of these developments have had their origin in courses offered in those colleges and universities where teachers and prospective teachers have been brought into contact with newer methods and apparatus used in teach-

ing, diagnostic, prognostic, and remedial reading. The time is near at hand when teacher-training institutions can obtain the services of visiting professors who are interested in teaching these technical courses, and who will bring their laboratory equipment with them. In this way technical training in the use of instrumentation can be brought even to communities where local institutions do not have fully equipped laboratories. The modern trend toward the use of instrumentation in the classroom will make courses of this nature an essential part of the teacher-training curriculum.

It has been shown that developments in the past few years have aided in the solution of some of the problems confronting educators, and as scientific studies are carried forward many more problems will be investigated. For instance, in addition to the many problems in the field of reading in English, there are those involving the teaching of foreign languages and other subjects, which may be studied more effectively as new techniques and apparatus are developed. Even at the present time objective reading tests are being devised which may be given with the Metron-O-Scope. There are many advantages in this type of testing. Motivation and interest are taken care of, as the readers are forced to follow the material at a uniform speed, which may be decreased or increased instantly to meet the need

of the moment. The reaction time of the individual is probably a very definite factor to be considered in any testing program, and, as every student has equal opportunity to see and react to every section of the material at the same instant, individual variations are readily determined by comprehension tests relating to the material presented. Further, in this group performance emotional and physical reactions which might affect the testing process can be noted by the teacher, who is free to observe the situation in general because the reading aspect of the testing situation may be adequately controlled. It is not lack of problems but the dearth of techniques and apparatus with which to study problems which retards research. As new developments take place, whole new fields of research open up, and it is in this way that science makes progress.

The research reported in this book started with certain premises. These premises and the conclusions drawn from the experimental data are presented in the following statements:

1. The ability to read with speed and comprehension is one of the greatest assets a child can acquire. He must be definitely trained to react more readily and effectively to the reading demands that are being made, and will be made, upon him as the total amount of printed material and the range of the school curriculum continue to expand in our ever changing society.

2. A binocular eye-movement photograph or reading-graph is indispensable in any comprehensive visual or reading examination, as by this means only can the irregularities shown in the behavior of the eyes while they are actually at work be objectively determined. The maturity of reading habits, as indicated by the mechanical efficiency shown by the photographic record, is the only *objective information* which permits comparison between groups or individuals, and furnishes a definite prognostic test for checking corrective measures.

3. Since our whole educational scheme depends primarily upon the function of vision, eye discomfort in children and its causes must be considered in the educational program. Almost half of the school population complains of eye discomfort in some form, and the majority of the cases underlying this discomfort can be eliminated. Although research workers cannot, in many instances, show a *direct* relationship between visual defects and reading inefficiency, it is generally admitted that these defects may decidedly influence the total capacity of the individual. He may be utterly unconscious of any impediment as long as the errors are within his "physiological limit" of compensation for such defects. The teacher, as a rule, is unaware of these disturbing influences unless they are revealed by special tests.

4. Every individual has a "physiological limit" or capacity for reading, which cannot be exceeded, just as he has a "physiological limit" of compensation for various defects. It is thought that the size and functional efficiency of the macular area determine the span of recognition. The fact that the span of recognition in some cases cannot be increased appreciably by any type of training seems to indicate that these subjects have attained approximately their maximum capacity through the ordinary school procedures. In the majority of cases, however, special training results in improvement, which, in turn, seems to indicate that these subjects have been reading habitually below their capacity. Practically everyone can be taught to read, and in almost every case effective reading speed can be increased by training. Usually it is not enough to tell the subject *how* he should read. Experiments show that it is far more effective to *control* the reading in such way that he is forced to practice during definite training periods desired habits of attack on print, which he can successfully apply in other reading situations. In this way old habits are broken down and new ones established.

5. In teaching reading *the mechanical process should be controlled and developed simultaneously with the interpretative process.* It is recognized that these processes are not independent. Although no single method of reading instruction

will be suitable for all children, it is obvious that as part of every reading program the instruction should be so controlled as to condition effective rhythmical left-to-right eye-movements.

6. Many maturation or reading-readiness problems will not develop if children are taught to control their eyes in left-to-right movements before actual reading instruction is introduced. Photographs of the eye-movements of first-graders show a decided lack of uniformity in eye behavior, and it is from this disorganized activity that the teacher must develop reading efficiency which will promote educational achievement. Developments in the field of reading have shown that controlled reading is a desirable feature in the daily routine of every classroom, and that it provides a highly motivated technique of instruction which appeals to both teachers and pupils. It seems reasonable to assume that the universal adoption of such a technique would not increase materially the cost of instruction. The fact remains that a uniform method of instruction embodying both *oral* and *silent* reading, and directed toward prevention of reading disability, would eliminate much of the reteaching and remedial work now carried on.

7. Much of the near-point work in the first few years of school life, which ultimately contributes to various visual defects, could be eliminated by making it possible for children to spend part of

the daily reading period in using their eyes for distance vision. While this preventive measure of distance reading is being employed, the child can be conditioned to acquire greater precision of eye control, which is recognized as desirable in rapid, accurate book reading.

8. Every child must necessarily learn to control and co-ordinate convergence and accommodation in fusing retinal images for binocular single vision. Every teacher of reading, therefore, should have at her command a technique that not only will facilitate the teaching of reading, but will aid the child in developing accurate binocular fixation, so necessary for quick perception in reading.

9. Most reading difficulties can be prevented if provision is made for individual differences in the first teaching of this important subject. It is recognized that reading disability exists at all levels of intelligence. The range of variability clearly indicates that poor readers and non-readers do not constitute separate and distinct classes, but are part of a graded series which extends from the poorest to the most efficient reader.

10. Many of the excellent texts and supplementary books prepared for the elementary school can be used more effectively if pupils acquire greater mechanical skill in gleaning the content and suitable training in the intelligent use of printed materials.

11. There should be closer co-operation between parents, educators, physicians, and eye specialists in preventing and correcting defects which have a direct bearing on general school efficiency. The development of techniques, instruments, and materials for correcting visual and physical defects, and improving reading ability, makes it possible to plan a program in which each of these individuals has a well-defined part. The teacher is in the key position, if she is furnished with proper equipment, to screen-out pupils who need the services of a specialist.

12. Teachers of reading welcome more than ever before tangible suggestions concerning diagnostic, teaching, and corrective procedures that can be carried into the classroom. Some have become bewildered, perhaps, by the large number of stated defects which results from breaking down reading deficiencies into their component parts, any of which might or might not influence general reading efficiency. Especially is this true in systems where the school authorities do not co-operate by furnishing the teachers with suitable materials for even a meager testing and remedial program. Regardless of the type of school system, or the training of the teacher, if an adequate program of teaching and corrective work in reading is to be carried on, the teacher must have suitable equipment and materials.

BIBLIOGRAPHY

AMES, A., JR.; GLIDDON, GORDON H.; and OGLE, KENNETH N. "Size and Shape of Ocular Images, I," *Archives of Ophthalmology*, VII (April, 1932), 576–97. Chicago: American Medical Association, 535 North Dearborn St.

AMES, A., JR., and OGLE, KENNETH N. "Size and Shape of Ocular Images, III," *Archives of Ophthalmology*, VII (June, 1932). 904–24. Chicago: American Medical Association, 535 North Dearborn St.

ARMENTROUT, W. D. "Professional Preparation of Elementary Teachers," *Education*, XLV (March, 1925), 385–91. Boston: Palmer Co., 120 Boylston St.

BAKER, HARRY J., and LELAND, BERNICE. *In Behalf of Non-Readers.* Bloomington, Ill.: Public School Publishing Co., 1934. Pp. 39.

BARKER, DOROTHY B. "Eye-Dominance and Its Association with Hand-Dominance," *British Journal of Physiological Optics*, X (April, 1936), 18–30. London, England: British Optical Association, 65 Brook St., W. 1.

BARKER, WILLIAM B. "Binocular Vision," *British Journal of Physiological Optics*, X (April, 1936), 64–72. London, England: British Optical Association, 65 Brook St., W. 1.

BERENS, CONRAD, M.D.; LOSEY, RAY R., M.D.; and HARDY, LEGRAND H., M.D. "Routine Examinations of the Ocular Muscles and Non-operative Treatment," *American Journal of Ophthalmology*, X (December, 1927), 910–18. Chicago: Ophthalmic Publishing Co., 7 West Madison St.

BERKOWITZ, J. H. *The Eyesight of School Children.* U.S. Bureau of Education Bulletin 1919, No. 65. Washington: Government Printing Office, 1920. Pp. 128.

BETTS, EMMETT A. "Reading Disability Correlates," *Education*, LVI (September, 1935), 18–24. Boston: Palmer Co., 120 Boylston St.

Betts, Emmett A. *Prevention and Correction of Reading Difficulties.* Evanston: Row, Peterson & Co., 1936. Pp. xiv+402.

Bielschowsky, Alfred, M.D. "Lectures on Motor Anomalies of the Eyes, III: Paralyses of the Conjugate Movements of the Eyes," *Archives of Ophthalmology,* XIII (April, 1935), 569–83. Chicago: American Medical Association, 535 North Dearborn St.

———. "Lectures on Motor Anomalies of the Eyes, IV: Functional Neurosis: Etiology, Prognosis, and Treatment of Ocular Paralysis," *ibid.,* XIII (May, 1935), 751–70. Chicago: American Medical Association, 535 North Dearborn St.

———. "Congenital and Acquired Deficiencies of Fusion," *American Journal of Ophthalmology,* XVIII (October, 1935), 925–37. Chicago: Ophthalmic Publishing Co., 7 West Madison St.

Blake, Mabelle B., and Dearborn, Walter F. "The Improvement of Reading Habits," *Journal of Higher Education,* VI (February, 1935), 83–88. Columbus, Ohio: Ohio State University.

Breitwieser, J. V. "Training for Rapid Reading," *Application of Psychology to Education,* pp. 15–17. Studies 4, 5, 6, 7. Berkeley, Calif.: Bureau of Research in Education, University of California, 1922.

Bressler, J. L., M.D., "Treatment of Strabismus: Influence of Orthoptic Training on Results of Operation," *Archives of Ophthalmology,* XVI (September, 1936), 433–42.

Brooks, Fowler D. *The Applied Psychology of Reading.* New York: D. Appleton–Century Co., Inc., 1926. Pp. xvii+278.

Buswell, Guy T. "The Relationship between Eye-Perception and Voice-Response in Reading," *Journal of Educational Psychology,* XII (April, 1921), 217–27. Baltimore: Warwick & York, Inc.

———. *Fundamental Reading Habits: A Study of Their Development.* Supplementary Educational Monographs, No. 21. Chicago: University of Chicago, 1922. Pp. xiv+150.

Buswell, Guy T., and Judd, Charles H. *Summary of Educational Investigations Relating to Arithmetic.* Supplementary Educational Monographs, No. 27. Chicago: University of Chicago, 1925.

BUSWELL, GUY T., and JOHN, LENORE. *The Vocabulary of Arithmetic.* Supplementary Educational Monographs, No. 38. Chicago: University of Chicago, 1931. Pp. xi+146.

BUSWELL, GUY T. *How People Look at Pictures: A Study of the Psychology of Perception in Art.* Chicago: University of Chicago Press, 1936. Pp. xv+198.

CARLETON, ELMER H., M.D., and MADIGAN, LEO F. "Size and Shape of Ocular Images, II," *Archives of Ophthalmology,* VII (May, 1932), 720–38. Chicago: American Medical Association, 535 North Dearborn St.

CATTELL, JAMES MCKEEN. "The Inertia of the Eye and Brain," *Brain,* VIII (October, 1885), 295–312. New York: Macmillan Co.

———. "The Time It Takes To See and Name Objects," *Mind,* XI (January, 1886), 63–65. New York: Macmillan Co.

CLARK, BRANT. "A Camera for Simultaneously Recording the Horizontal and Vertical Movements of Both Eyes," *American Journal of Psychology,* XLVI (April, 1934), 325–26. Ithaca, N.Y.: Cornell University.

———. "The Effects of Binocular Imbalance in the Behavior of the Eyes during Reading," *Journal of Educational Psychology,* XXVI (October, 1935), 530–38. Baltimore: Warwick & York, Inc.

———. "Eye Movement Study of Stereoscopic Vision," *American Journal of Psychology,* XLVIII (January, 1936), 82–97. Ithaca, N.Y.: Cornell University.

———. "Eye-Movement Photography as a Diagnostic Method in the Determination of Reading Disability," *American Journal of Optometry,* XIII (April, 1936), 121–29. Minneapolis, Minn.

———. "A Case of High Esophoria Studied by Eye-Movement Photography," *American Journal of Ophthalmology,* XIX (June, 1936), 503–7. Chicago: Ophthalmic Publishing Co., 7 West Madison St.

COLE, LUELLA PRESSEY. *A Manual of Reading Exercises for Freshmen.* Columbus, Ohio: Ohio State University Press, 1928. Pp. 112.

COMSTOCK, LULA MAE. *Per Capita Cost in City Schools, 1929–30.* U.S. Bureau of Education, Pamphlet No. 19, April, 1931. Washington: Government Printing Office, 1931.

Conserving the Sight of School Children. A report of the Joint Committee on Health Problems in Education, Publication 6. New York: National Society for the Prevention of Blindness, Inc., 1935 (rev.). Pp. 54.

CRIDER, BLAKE. "The Lack of Cerebral Dominance as a Cause of Reading Disabilities," *Childhood Education*, X (February, 1934), 238–39, 270. Washington: Association for Childhood Education.

———. "Certain Visual Functions in Relation to Reading Disabilities," *Elementary School Journal*, XXV (December, 1934), 295–97. Chicago: University of Chicago.

DEARBORN, WALTER F. *The Psychology of Reading.* Columbia University Contributions to Philosophy, Psychology and Education, Vol. XIV, No. 1. (Also listed in Archives of Philosophy, Psychology and Scientific Methods, No. 4.) New York: Columbia University Press, 1906. Pp. 134.

———. "Teaching Reading to Non-Readers," *Elementary School Journal*, XXX (December, 1929), 266–70. Chicago: University of Chicago.

———. "Structural Factors Which Condition Special Disability in Reading," *Proceedings and Addresses of the Fifty-seventh Annual Session of the American Association on Mental Deficiency.* (Boston, Mass., May 29–June 3, 1933), XXXVIII, 268–83. Godfrey, Ill.: Groves B. Smith, secretary. (Beverly Farm, Inc.)

DEARBORN, WALTER F., and COMFORT, FORREST D. "Differences in the Size and Shape of Ocular Images as Related to Defects in Reading" (a preliminary report of the Psycho-Educational Clinic of the Harvard Graduate School of Education), *Elementary English Review*, XII (May, 1935), 131–32.

DODGE, RAYMOND, and CLINE, THOMAS S. "The Angle Velocity of Eye Movements," *Psychological Review*, VIII (March, 1901), 145–57. Princeton, N.J.: Psychological Review Co.

DODGE, RAYMOND. "Five Types of Eye Movement in the Horizontal Meridian Plane of the Field of Regard," *American Jour-*

nal of Physiology, VIII (January, 1903), 307–29. Baltimore: American Physiological Society, 19 West Chase St.

———. *An Experimental Study of Visual Fixation*. Psychological Review Monograph Supplements, No. 35 (Vol. VIII, No. 4 [1907]). Princeton, N.J.: Psychological Review Co. Pp. iv+96. (Trans. "Eine experimentelle Studie der visuellen Fixation," *Zeitschrift für Psychologie und Physiologie der Sinnesorgane*, LII (1909), 321–422.)

Dodge, Raymond, and Diefendorf, Allan R., M.D. "An Experimental Study of the Ocular Reactions of the Insane from Photographic Records," *Brain*, XXXI (November, 1908), 451–89. New York: Macmillan Co.

Dodge, Raymond, and Benedict, F. G., M.D. *Psychological Effects of Alcohol*. Carnegie Institution of Washington, Publication No. 232. Washington: Carnegie Institution of Washington, 1915. Pp. 281.

Dodge, Raymond. "A Mirror-Recorder for Photographing the Compensatory Movements of Closed Eyes," *Journal of Experimental Psychology*, IV (June, 1921), 165–74. Princeton, N.J.: Psychological Review Co.

Dodge, Raymond; Travis, Roland C.; and Fox, James C., Jr., M.D. "Optic Nystagmus, III: Characteristics of the Slow Phase," *Archives of Neurology and Psychiatry*, XXIV (July, 1930), 21–34. Chicago: American Medical Association, 535 North Dearborn St.

Dodge, Raymond, and Miles, Walter R. "A Floating Mirror Technique for Recording Eye Movements," *American Journal of Psychology*, XLIII (January, 1931), 124–26. Baltimore: Warwick & York, Inc.

Dodge, Raymond. *Conditions and Consequences of Human Variability*. New Haven: Yale University Press, 1931. Pp. x+162.

Douglas, Aubrey A. *The American School System*, pp. 352–71. New York: Farrar & Rinehart, Inc., 1934. Pp. xii+491.

Douglas, Oscar B. "The Relation of Peripheral Vision to Reading." Unpublished Doctor's dissertation, Department of Education, University of Chicago, 1928. Pp. xi+323.

Duffy, Gertrude B., and Durrell, Donald D. "Third Grade Difficulties in Oral Reading," *Education*, LVI (September, 1935), 37–40. Boston: Palmer Co., 120 Boylston St.

Duke-Elder, Sir William Stewart, M.D. *Text Book of Ophthalmology*, Vol. I: *The Development, Form and Function of the Visual Apparatus*. St. Louis: C. V. Mosby Co., 1933. 3 vols. Pp. xxviii+1124.

Durrell, Donald D. "Tests and Corrective Procedures for Reading Disabilities," *Elementary English Review*, XII (April, 1935), 91–95. Detroit, Mich.: Elementary English Review.

———. "Providing for Individual Differences in Reading," *Education*, LVI (September, 1935), 3–36. Boston: Palmer Co., 120 Boylston St.

Eames, Thomas, H. "A Comparison of the Ocular Characteristics of Unselected and Reading Disability Groups," *Journal of Educational Research*, XXV (March, 1932), 211–15. Bloomington, Ill.: Public School Publishing Co.

———. "Low Fusion Convergence as a Factor in Reading Disability," *American Journal of Ophthalmology*, XVII (August, 1934), 709–10. Chicago: Ophthalmic Publishing Co., 7 West Madison St.

———. "Improvement in School Eye Testing," *Education*, LVI (September, 1935), 14–17. Boston: Palmer Co., 120 Boylston St.

———. "Frequency Study of Physical Handicaps in Reading Disability and Unselected Groups," *Journal of Educational Research*, XXIX (September, 1935), 1–5. Bloomington, Ill.: Public School Publishing Co.

———. "Restrictions of the Visual Field as Handicaps to Learning," *ibid.*, XXIX (February, 1936), 460–65. Bloomington, Ill.: Public School Publishing Co.

Eurich, Alvin C. "The Reliability and Validity of Photographic Eye-Movement Records," *Journal of Educational Psychology*, XXIV (February, 1933), 118–22. Baltimore: Warwick & York, Inc.

———. "Additional Data on the Reliability and Validity of Photographic Eye-Movement Records," *ibid.*, XXIV (May, 1933), 380–84.

Farris, L. P. "Visual Defects as Factors Influencing Achievement in Reading," *California Journal of Secondary Education*, X (October, 1934), 50–51. Berkeley, Calif.: California Society of Secondary Education.

FELDMAN, JACOB B., M.D. "Orthoptic Treatment of Concomitant Squint," *Archives of Ophthalmology*, XIII (March, 1935), 419–34. Chicago: American Medical Association, 535 North Dearborn St.

FERNALD, GRACE M., and KELLER, HELEN B. "The Effect of Kinaesthetic Factors in the Development of Word Recognition in the Case of Non-Readers," *Journal of Educational Research*, IV (December, 1921), 355–77. Bloomington, Ill.: Public School Publishing Co.

FRANZ, SHEPHERD I., and OTHERS. *Studies in Cerebral Function, I–IX*. University of California at Los Angeles Studies in Education, Philosophy and Psychology, I, 65–136. Berkeley, Calif.: University of California, 1933.

FUTCH, OLIVIA. "A Study of Eye-Movements in the Reading of Latin," *Journal of General Psychology*, XIII (1935), 434–63. Worcester, Mass.: Clark University.

GATES, ARTHUR I. *The Improvement of Reading*. New York: Macmillan Co., 1935 (rev.). Pp. xvi+668.

GIFFORD, SANFORD R., M.D. *A Handbook of Ocular Therapeutics*. Philadelphia: Lea & Ferbiger, 1932. Pp. viii+272.

GILLINGHAM, ANNA, and STILLMAN, BESSIE W. *Remedial Work for Reading, Spelling, and Penmanship*. New York: Educational Records Bureau, 437 West Fifty-ninth St., 1936. Pp. 170.

GRAY, CLARENCE T. *Types of Reading Ability as Exhibited through Tests and Laboratory Experiments*. Supplementary Educational Monographs, No. 2. Chicago: University of Chicago, 1917. Pp. xiii+196.

———. *Deficiencies in Reading Ability: Their Diagnosis and Remedies*. New York: D. C. Heath & Co., 1922. Pp. xiv+420.

———. "The Purpose and Values of Oral Reading in the Intermediate and Upper Grades of the Elementary School," *Elementary School Journal*, XXIX (January, 1929), 335–43. Chicago: University of Chicago.

GRAY, WILLIAM S.; KIBBE, DELIA; LUCAS, LAURA; and MILLER, LAWRENCE W. *Remedial Cases in Reading: Their Diagnosis and Treatment*. Supplementary Educational Monographs, No. 22. Chicago: University of Chicago, 1922. Pp. vii+208.

GRAY, WILLIAM S. *Summary of Investigations Relating to Reading.* Supplementary Educational Monographs, No. 28. Chicago: University of Chicago, 1925. Pp. vii+275.

GRAY, WILLIAM S., and WHIPPLE, GERTRUDE. *Improving Instruction in Reading: An Experimental Study.* Supplementary Educational Monographs, No. 40. Chicago: University of Chicago, 1935. Pp. xiii+226.

GRAY, WILLIAM S., and OTHERS. *Special Methods and Psychology of the Elementary School Subjects.* Review of Educational Research, V, No. 1, 54–69, 111–14. Washington: American Educational Research Association of the National Education Association, 1935.

GRAY, WILLIAM S. "The Place of Oral Reading in an Improved Program of Reading," *Elementary School Journal,* XXXVI (March, 1936), 517–26. Also in *The Application of Research Findings to Current Educational Practices,* pp. 91–98. Official report of the American Educational Research Association, 1935. Washington: American Educational Research Association of the National Education Association, 1935.

———. "The Nature and Extent of Reading Deficiencies among College Students." An address delivered at the Joint Meeting of the National Society of College Teachers of Education and the American Educational Research Association, February 25, 1936. Sixty-sixth Annual Convention of the Department of Superintendence of the National Education Association, St. Louis, Mo., February 22–27, 1936.

———. "Need of Co-operation between Laboratory and Classroom," *Journal of Educational Research,* XXIX (February, 1936), 484–85. Bloomington, Ill.: Public School Publishing Co.

GREENE, HARRY A. *A Remedial Program for Silent Reading in the High School.* Iowa University Extension Division, Bulletin No. 240. Iowa City, Iowa: University of Iowa, 1929.

GUIBOR, GEORGE P., M.D. "Practical Details in the Orthoptic Treatment of Strabismus," *Archives of Ophthalmology,* XII (December, 1934), 887–98. Chicago: American Medical Association, 535 North Dearborn St.

GUILFORD, J. P. " 'Fluctuations of Attention' with Weak Visual Stimuli," *American Journal of Psychology*, XXXVII (October, 1927), 534–83.

GUILFORD, J. P., and DALLENBACH, KARL M. "A Study of Autokinetic Sensation," *American Journal of Psychology*, XL (January, 1928), 83–91. Ithaca, N.Y.: Cornell University.

GUILFORD, J. P. "Ocular Movements and the Perception of Time," *Journal of Experimental Psychology*, XII (August, 1929), 259–66. Princeton, N.J.: Psychological Review Co.

GUILFORD, J. P., and HELSON, HARRY. "Eye-Movements and the Phi-Phenomenon," *American Journal of Psychology*, XLI (October, 1929), 595–606. Ithaca, N.Y.: Cornell University.

GUILFORD, J. P., and HACKMAN, ROY B. "Varieties and Levels of Clearness Correlated with Eye Movements," *American Journal of Psychology*, XLVIII (July, 1936), 371–88.

HENDERSON, OLIVE G., and ROWELL, HUGH G., M.D. *Good Eyes for Life*. New York: D. Appleton–Century Co., Inc., 1933. Pp. xiv+203.

HICKS, AVERY M., M.D., and HOSFORD, GEORGE N., M.D. "Orthoptic Treatment of Squint," *Archives of Ophthalmology*, XIII (June, 1935), 1026–37. Chicago: American Medical Association, 535 North Dearborn St.

HIGLEY, HENRY RICH. *Strabismus: Causes and Correction*. Pittsfield, Mass.: Henry Rich Higley, 1934. Pp. xix+193.

HOLLAND, B. F. "Special Apparatus in the Laboratory of Educational Psychology University of Texas," *American Journal of Psychology*, XLV (January, 1933), 139–41. Ithaca, N.Y.: Cornell University.

HOVIUS, CAROL. *Following Printed Trails*. New York: D. C. Heath, 1936. Pp. x+371.

HUEY, EDMUND B. *The Psychology and Pedagogy of Reading*. (Also published with title: *The History and Pedagogy of Reading*.) New York: Macmillan Co., 1908. Pp. xvi+469.

HUGHES, WENDELL L., M.D. "Aniseikonia," *American Journal of Ophthalmology*, XIX (August, 1936), 686–88.

JACQUES, LOUIS. *Fundamental Refraction and Orthoptics*. Los Angeles, Calif., 1936. Pp. xii+209.

Improvement in the Teaching of Reading. Bureau of Research Monographs, No. 1. Baltimore, Md.: Baltimore Department of Education, Bureau of Research, 1926. Pp. 129.

JASPER, HERBERT H., and WALKER, ROBERT Y. "The Iowa Eye-Movement Camera," *Science*, LXXIV (September 18, 1931), 291–93. New York: Science Press.

JAVAL, LOUIS EMIL. "Essai sur la physiologie de la lecture," *Annales d'oculistique*, LXXXII (novembre–decembre, 1879), 242–53.

JUDD, CHARLES H.; MCALLISTER, CLOYD N.; and STEELE, W. M. *General Introduction to a Series of Studies of Eye Movements by Means of Kinetoscopic Photographs.* Psychological Review Monograph Supplements, No. 29 (VII [March, 1905], 1–16). Princeton, N.J.: Psychological Review Co.

JUDD, CHARLES H., and OTHERS. *Reading: Its Nature and Development.* Supplementary Educational Monographs, No. 10. Chicago: University of Chicago, 1918. Pp. 192.

JUDD, CHARLES H., and BUSWELL, GUY T. *Silent Reading: A Study of the Various Types.* Supplementary Educational Monographs, No. 23. Chicago: University of Chicago, 1922. Pp. xiv+160.

JUDD, CHARLES H. "Raising the Level of the Education of Teachers," *School Review*, XLIV (April, 1936), 257–67. Chicago: University of Chicago.

KENT, BLANCHE. "Procedures in Beginning Reading," *Childhood Education*, XI (March, 1935), 262–64. Washington: Association for Childhood Education.

KLAPPER, PAUL. *Teaching Children To Read.* New York: D. Appleton–Century Co., Inc., 1926 (4th ed, rev. and enl.). Pp. xxii+304.

KORNHAUSER, ARTHUR W. *How To Study*, pp. 18–24. Chicago: University of Chicago Press, 1924. Pp. vii+43.

LEBENSOHN, JAMES E., M.D. "Oculovisceral Reflexes—Oculogastric Reflex Experimentally Demonstrated," *American Journal of Ophthalmology*, XII (July, 1929), 562–68. Chicago: Ophthalmic Publishing Co., 7 West Madison St.

———. "Gastric Disorders of Asthenopic Origin," *Illinois Medical Journal*, LVI (August, 1929), 106–8. Oak Park, Ill.: Illinois State Medical Association.

Lebensohn, James E. "The Mechanics of Reading," *Hygeia*, XIII (November, 1935), 987–89. Chicago: American Medical Association, 535 North Dearborn St.

McAllister, Cloyd N. "The Fixation of Points in the Visual Field," *Psychological Review Monograph Supplements*, VII (March, 1905), 17–53. Princeton, N.J.: Psychological Review Co.

McCallister, James Maurice. *Remedial and Corrective Instruction in Reading*. New York: D. Appleton-Century Co., 1936. Pp. XVIII+300.

McLeod, Beatrice. *Teachers Problems with Exceptional Children, I: Blind and Partially Seeing Children*. U.S. Bureau of Education, Pamphlet No. 40. Washington: Government Printing Office, 1935. Pp. 32.

Madigan, Leo Y., and Carleton, Elmer H., M.D. *Clinical Treatment of Aniseikonia*. Southbridge, Mass.: American Optical Co., 1934. (Multigraphed.)

Marlow, F. W., M.D. "Muscle Imbalance in Myopia," *Archives of Ophthalmology*, XIII (April, 1935), 584–97. Chicago: American Medical Association, 535 North Dearborn St.

May, Charles H., M.D. *Manual of the Disease of the Eye*. Baltimore: William Wood & Co., 1934 (14th ed., rev.). Pp. 496.

Mayou, Sheila. "The Result of Orthoptic Treatment in Divergent Strabismus," *British Journal of Ophthalmology*, XIX (January, 1935), 37–46. London, England: 24 Thayer St., Marylebone, W. 1.

Miles, Walter R., and Shen, Eugene. "Photographic Recording of Eye Movements in the Reading of Chinese in Vertical and Horizontal Axes," *Journal of Experimental Psychology*, VIII (October, 1925), 344–62. Princeton, N.J.: Psychological Review Co.

Miles, Walter R. "The Peep-Hole Method for Observing Eye-Movements in Reading," *Journal of General Psychology*, I (1928), 373–74. Worcester, Mass.: Clark University.

Miles, Walter R., and Bell, H. M. "Eye Movement Records in the Investigation of Study Habits," *Journal of Experimental Psychology*, XII (October, 1929), 450–58. Princeton, N.J.: Psychological Review Co.

MILES, WALTER R., and SEGEL, DAVID. "Clinical Observation of Eye Movements in the Rating of Reading Ability," *Journal of Educational Psychology*, XX (October, 1929), 520–29. Baltimore: Warwick & York, Inc.

MILES, WALTER R., and LASLETT, H. R. "Eye Movement and Visual Fixation during Profound Sleepiness," *Psychological Re-Review*, XXXVIII (January, 1931), 1–13. Princeton, N.J.: Psychological Review Co.

MILLS, LLOYD, M.D. "The Functions of the Eyes in the Acquisition of an Education," *Journal of American Medical Association*, XCIII (September 14, 1929), 841–45. Chicago: American Medical Association, 535 North Dearborn St.

MONROE, MARION. *Children Who Cannot Read.* Chicago: University of Chicago Press, 1932. Pp. xvi+205.

———. "Diagnosis and Treatment of Reading Disabilities," *Educational Diagnosis*, pp. 201–28. Thirty-fourth Yearbook of the National Society for the Study of Education. Bloomington, Ill.: Public School Publishing Co., 1935.

MORSE-PECKHAM, RAY. "An Investigation of the Visual Efficiency of 10,000 School Children and the Correlation of Vision and Scholarship," *American Journal of Optometry*, XIII (September, 1936), 321–43.

NATIONAL COMMITTEE ON READING. *Twenty-fourth Yearbook of the National Society for the Study of Education*, Part I. Bloomington, Ill.: Public School Publishing Co., 1925. Pp. x+335.

NATIONAL EDUCATION ASSOCIATION (Research Division). "Better Reading Instruction," *Research Bulletin of the National Education Association*, XIII (November, 1935), 273-325. Washington: Research Division of the National Education Association.

NEWELL, NANCY. "For Non-readers in Distress," *Elementary School Journal*, XXXII (November, 1931), 183–95. Chicago: University of Chicago.

O'BRIEN, JOHN ANTHONY. *Silent Reading.* New York: Macmillan Co., 1921. Pp. xvii+289.

———. *Reading: Its Psychology and Pedagogy.* New York: D. Appleton-Century Co., Inc., 1926. Pp. xxviii+308.

ORTON, SAMUEL T. "An Impediment to Learning To Read—a Neurological Explanation of the Reading Disability," *School*

and Society, XXVIII (September 8, 1928), 286–90. New York: Science Press.

———. "The 'Sight Reading' Method of Teaching Reading as a Source of Reading Disability," *Journal of Educational Psychology*, XX (February, 1929), 135–43. Baltimore: Warwick & York, Inc.

Park, George E., M.D. "The Precision Anglometer," *Archives of Ophthalmology*, XV (April, 1936), 703–9. Chicago: American Medical Association, 535 North Dearborn St.

Parr, Frank W., and Nemsek, Claude L. "The Inefficient Silent Reader in College," *Peabody Journal of Education*, VII (March, 1930), 299–303. Nashville, Tenn.: George Peabody College for Teachers.

Pascal, Joseph I., M.D. "Myopia and Exophoria," *Archives of Ophthalmology*, XIV (October, 1935), 624–26. Chicago: American Medical Association, 535 North Dearborn St.

Paul, Vera Alice. *Present Trends of Thought on Oral Reading*. College of Education Series, No. 31. University of Iowa Extension Division, Bulletin No. 299. Iowa City, Iowa: University of Iowa, 1932.

Pennell, Mary E., and Cusack, Alice M. *The Teaching of Reading for Better Living*. New York: Houghton Mifflin Co., 1935. Pp. vii+469.

Peter, Luther C., M.D. "Technique of Orthoptic Training in Squint," *Archives of Ophthalmology*, XIV (December, 1935), 975–84. Chicago: American Medical Association, 535 North Dearborn St.

Pitkin, Walter B. *The Art of Rapid Reading*. New York: McGraw Hill Book Co., Inc., 1929. Pp. x+233.

Points of View on the Problem of "Reading Readiness." Reading Readiness Committee of the International Kindergarten Union, 1929–30. Washington: Association for Childhood Education.

Posey, William C. *Hygiene of the Eye*. Philadelphia: J. B. Lippincott Co., 1918. Pp. x+344.

Pyle, W. H. "The Reading Span," *Elementary School Journal*, XXIX (April, 1929), 597–602. Chicago: University of Chicago.

REBERT, GORDON NEVIN. "A Laboratory Study of the Reading of Formulas and Familiar Numerals." Doctor's dissertation, Department of Education, University of Chicago, 1929. Pp. xiii+417. ("A Laboratory Study of the Reading of Familiar Numerals," *Journal of Educational Psychology*, XXIII [January, 1932], 34–45; "A Laboratory Study of the Reading of Familiar Formulas," *ibid.*, XXIII [March, 1932], 192–203).

Report of the National Committee on Reading. Twenty-fourth Yearbook of the National Society for the Study of Education, Part I. Bloomington, Ill.: Public School Publishing Co., 1925.

RODIN, FRANK H., M.D., "Ophthalmologist, Oculist, Optician, and Optometrist," *Archives of Ophthalmology*, XVI (October, 1936), 609–23.

ROGERS, JAMES F., M.D. *What Every Teacher Should Know about the Physical Condition of Her Pupils.* U.S. Bureau of Education, Health Education, No. 18. Washington: Government Printing Office, 1924. Pp. 23.

SCHMIDT, WILLIAM ANTON. *An Experimental Study in the Psychology of Reading.* Supplementary Educational Monographs, No. 2. Chicago: University of Chicago, 1917. Pp. iv+192.

SELZER, CHARLES A. *Lateral Dominance and Visual Fusion.* Harvard Monographs in Education, No. 12. Cambridge, Mass.: Harvard University, 1933. Pp. 119.

SHERER, CHARLES R. "Does the Present High School Curriculum in Mathematics Prepare Students for College?" *Texas Mathematics Teachers Bulletin,* XVIII, No. 1, 43–48. Austin, Tex.: University of Texas, 1934.

SMITH, CHARLES A., and JENSEN, MYRTLE R. "Educational, Psychological, and Physiological Factors in Reading Readiness, I," *Elementary School Journal,* XXXVI (April, 1936), 583–94. Chicago: University of Chicago.

SMITH, NILA B. *American Reading Instruction.* New York: Silver Burdett & Co., 1934. Pp. x+287.

SMITH, WILLIAM ANTON. *The Reading Process.* New York: Macmillan Co., 1922. Pp. xii+267.

Statistical Summary of Education, 1931–32. The Preface to the biennial survey of education in the United States, 1930–32.

Bulletin 1933, No. 2. Washington: Government Printing Office, 1934.

STONE, CLARENCE R. "Case Studies in Reading and Deductions on Retardation," *Elementary School Journal*, XXXIV (September, 1933), 50–57. Chicago: University of Chicago.

STORM, GRACE E., and SMITH, NILA B. *Reading Activities in the Primary Grades.* Chicago: Ginn & Co., 1930. Pp. viii+376.

Students Handbook, pp. 28–36. Columbus, Ohio: Ohio State Department of Education, 1935.

SWANN, L. A. *The Ocular Muscles and the Treatment of Heterophoria and Heterotropia.* London, England: Hatton Press, Ltd., 72–78 Fleet St., E.C. 4, 1931. Pp. ix+208.

SWANSON, DONALD E., and TIFFIN, JOSEPH. "Betts' Physiological Approach to the Analysis of Reading Disabilities as Applied to the College Level," *Journal of Educational Research*, XXIX (February, 1936), 433–38. Bloomington, Ill.: Public School Publishing Co.

TAIT, E. F. "A Reciprocal Reflex System in the Accommodation-Convergence Relationship," *American Journal of Psychology*, XLV (October, 1933), 647–62. Ithaca, N.Y.: Cornell University.

TERRY, PAUL W. *How Numerals Are Read: An Experimental Study of the Reading of Isolated Numerals and Numerals in Arithmetical Problems.* Supplementary Educational Monographs, No. 18. Chicago: University of Chicago, 1922. Pp. xiv+110.

TINKER, MILES A. "Reading Reactions for Mathematical Formulae," *Journal of Experimental Psychology*, IX (December, 1926), 444–67. Princeton, N.J.: Psychological Review Co.

———. *A Photographic Study of Eye Movements in Reading Formulae.* Genetic Psychology Monographs, III, No. 2, 68–182. Worcester, Mass.: Clark University Press, 1928.

———. Numerals versus Words for Efficiency in Reading," *Journal of Applied Psychology*, XII (March, 1928), 190–99. Baltimore: Williams & Wilkins.

———. "How Formulae Are Read," *American Journal of Psychology*, XL (July, 1928), 476–83. Ithaca, N.Y.: Cornell University.

Tinker, Miles A. "An Apparatus for Recording Eye-Movements," *ibid.*, XLIII (January, 1931), 115–18. Ithaca, N.Y.: Cornell University.

———. "Diagnostic and Remedial Reading," *Elementary School Journal*, XXXIII (December, 1932, and January, 1933), 293–306, 346–58. Chicago: University of Chicago.

———. "Use and Limitations of Eye-Movement Measures of Reading," *Psychological Review*, XL (July, 1933), 381–87. Princeton, N.J.: Psychological Review Co.

Tinker, Miles A., and Frandsen, A. "Evaluation of Photographic Measures of Reading," *Journal of Educational Psychology*, XXV (February, 1934), 96–100. Baltimore: Warwick & York, Inc.

Tinker, Miles A. "Remedial Methods for Non-Readers," *School and Society*, XL (October 20, 1934), 524–26. New York: Science Press.

Travers, T. AB. *The Comparison between the Visual Results Obtained by Various Methods Employed for the Treatment of Concomitant Strabismus.* An essay for the Gifford Edmonds prize in ophthalmology. London, England: Geo. Pulman & Sons, Ltd., 24–27 Thayer St., W. 1, 1936. Pp. viii+127.

Travis, Roland C., and Dodge, Raymond. "Ocular Pursuit of Objects Which Temporarily Disappear," *Journal of Experimental Psychology*, XIII (February, 1930), 98–112. Princeton, N.J.: Psychological Review Co.

Travis, Roland C. "Experimental Studies in Ocular Behavior, I: The Dodge Mirror-Recorder for Photographing Eye-Movements," *Journal of General Psychology*, VII (October, 1932), 311–27. Worcester, Mass.: Clark University.

———. "Relationship of Ocular Latency and Speed to Intellectual Performance," *Journal of Psychology*, I, First Half (1935–36), 129–37. Provincetown, Mass.: The Journal Press, 2 Commercial St.

Traxler, Arthur E. *The Teaching of Corrective Reading in the Junior High School.* Bloomington, Ill.: Public School Publishing Co., 1934. Pp. 16.

Verhoeff, Frederick H., M.D. "A New Theory of Binocular Vision," *Archives of Ophthalmology*, XIII (February, 1935),

151–75. Chicago: American Medical Association, 535 North Dearborn St.

VERNON, M. D. "The Movements of the Eyes in Reading," *British Journal of Ophthalmology*, XII (March, 1928), 130–39. London, England: 24 Thayer St., Marylebone, W. 1.

———. "The Relationship of Subjective Experience to the Performance of Eye Movements," *ibid.* (*General Section*), XX (October, 1929), 161–72. London, England: Cambridge University Press.

———. "An Apparatus for Photographic Recording of Eye-Movements," *ibid.*, XXI (July, 1930), 64–67. London, England: Cambridge University Press.

———. *The Movements of the Eyes in Reading*. Medical Research Committee on the Physiology of Vision, 1930. Special Report Series, No. 148. London: H. M. Stationery Office.

———. *The Experimental Study of Reading*. London, England: Cambridge University Press, 1931. Pp. xv+190.

WALKER, ROBERT Y. "Parallel Recording of Vertical and Horizontal Oscillations by Means of an Erecting Prism," *American Journal of Psychology*, XLVII (October, 1935), 696–97. Ithaca, N.Y.: Cornell University.

WATSON, GEORGE. "Aetiology of Strabismus," *British Journal of Physiological Optics*, X (April, 1936), 12–17. London, England: British Optical Association, 65 Brook St., W. 1.

WEAVER, HOMER E. "Photographing Eye Movements during Music Reading," *Psychological Bulletin*, XXVIII (March, 1931), 211–12.

WITTY, PAUL A., and KOPEL, DAVID. "Factors Associated with the Etiology of Reading Disability," *Journal of Educational Research*, XXIX (February, 1936), 449–59. Bloomington, Ill. Public School Publishing Co.

WOODY, CLIFFORD. "Diagnostic and Remedial Instruction in Reading Factors Conditioning the Reading Process," *Seventeenth Annual Conference on Educational Measurements*, pp. 85–101. Bulletin of the School of Education, Indiana University, Vol. VI, No. 5. Bloomington, Ind.: Bureau of Co-operative Research, Indiana University School of Education, 1930.

YAGEMAN, LINDA. "Should All First-Grade Children Be Given a Reading Program?" *California Journal of Elementary Education*, III (February, 1935), 156–64. Sacramento, Calif.: California State Department of Education.

YOAKAM, GERALD A. *Reading and Study: More Effective Study through Better Reading Habits*. New York: Macmillan Co., 1928. Pp. xi+502.

———. "The Improvement of Reading in the Middle Grades," *Education*, LVI (September, 1935), 1–6. Boston: Palmer Co., 120 Boylston St.

INDEX

INDEX

PRINTED IN USA